Rio Blanco Oil Shale Company

Tract C-a

Annual Progress Report

January 1981 — December 1981

Gulf Oil Corporation / Standard Oil Company (Indiana)
A General Partnership
2851 South Parker Road, Aurora, Colorado 80014

Rio Blanco Oil Shale Company

ANNUAL PROGRESS REPORT
TRACT C-a

January 1981 — December 1981

Gulf Oil Corporation / Standard Oil Company (Indiana)
April, 1982

INDEX

RBOSC PROGRESS REPORT

JANUARY 1981 THROUGH DECEMBER 1981

SECTION I

INTRODUCTION AND SUMMARY

SECTION II

MINING

SECTION III

PROCESSING

SECTION IV

ORE STORAGE

SECTION V

SUPPORT FACILITIES

SECTION VI

ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY

SECTION VII

SUMMARY - ENVIRONMENTAL ASSESSMENT AND MONITORING

LIST OF FIGURES

LIST OF TABLES

SECTION 1

INTRODUCTION & SUMMARY

INTRODUCTION

The requirement to submit an Annual Progress Report (APR) on each anniversary date of the lease following approval of a development plan is contained in Section 1(c) (4) of the Environmental Stipulations to the Federal Oil Shale Lease (Serial No. C-20046) under which the Rio Blanco Oil Shale Company (RBOSC) is operating. The Gulf Oil Corporation and Standard Oil Company (Indiana) formed RBOSC as a general partnership to develop Tract C-a with the intention of engaging in the commerical production of oil shale. The legal description of Tract C-a, as defined in the Lease is:

T1S., R.99W., 6th P.M.

Sec. 32: E½, E½W½

Sec. 33: All

Sec. 34: W½, SE¼, W½NE¼, SE¼NE¼

T.2S., R.99W., 6th P.M.

Sec: 3: All

Sec. 4: All

Sec. 5: E½,E½W½ (incl. Lots 1, 2 and 3)

Sec. 8: E½

Sec. 9: All

Sec. 10: All

situated in the County of Rio Blanco, State of Colorado containing 5,089.70 acres, more or less.

INTRODUCTION (Cont.)

This APR describes the operational programs on Federal Tract C-a from January 1, 1981 through December 31, 1981. An environmental monitoring report is being submitted separately for the Calendar Year for air quality, meteorology, biological, and hydrologic data. Since this APR is defined to include a report of the monitoring programs, Section VII of this report contains a concise summary of the environmental programs for the 1981 Year.

Approval to develop Tract C-a was received by RBOSC on September 22, 1977. The reports which described operations from that date through the end of 1978, 1979, and 1980 were submitted to the *Deputy Conservation Manager - Oil Shale (DCM-OS) in Grand Junction, Colorado in April of 1979, 1980, and 1981 respectively. They also contained a summary of environmental assessment and monitoring for 1978, 1979, and 1980 Seasonal Year.

The information and background material contained in the previous reports is not included in this report. The previous reports were distributed by the Oil Shale Office (OSO) to many Federal, State, and local agencies, libraries and private industry. It is on open file in many public places for reference and should be referred to for operational and monitoring information prior to 1981.

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* The Oil Shale Office was in those years a unit of the United States Geological Survey, Dept. of Interior. During 1981 the office was reorganized as the Oil Shale Office of the Minerals Management Service headed by the Deputy Minerals Manager for Oil Shale.

1.2 ANNUAL PROGRESS REPORT (APR) ORGANIZATION AND USE

RBOSC's APR is written and organized to closely follow the organization of the first APR which in turn corresponded to the organization of the Detailed Development Plan (DDP) of May 1977. All major section titles of the APR are the same as the DDP except Section 7 which combines Section 7 and 8 of the DDP. By referencing the section number and title, the reader can refer to the previous APR or the DDP for additional information on the subject being addressed. Chapter titles have been utilized only as they pertain to the work being done during the report year, so they may vary from the previous APR or DDP.

A three-digit page numbering system is used throughout the APR. Page numbers are keyed to the chapters within the section; page 5-3-4, for example, refers to Section 5, Chapter 3, page 4. A similar system is used for figure and table numbers.

2.1 DESCRIPTION AND SCHEDULE OF PROJECT

At the end of 1981, RBOSC had nearly completed its four and one-half year development program designed to determine the technical, economical, and environmental viability of its modified in situ (MIS) recovery process. In 1981 the Modular Development Phase (MDP) program was reduced from three to two retorts which is now judged adequate operating experience to satisfy RBOSC's objectives. The MDP has been described in detail in previous APRs. The MDP mine development configuration for Retorts Zero and One is shown in Figure 1-2-1.

Retort One was ignited and burned as scheduled during 1981. The burn was successful. All aspects of the operation met or exceeded expectations. Retort One produced 24,444 barrels of oil for a yield of 68% of the available oil in place. At year end the retort was shut in and cooling down. Plans were being implemented to place the mine on standby until the next phase of Tract development is defined and approved.

Figure 1-2-2 illustrates the latest construction and operation schedule for the MIS program.

The next phase of development was intended to be a demonstration of surface retorting technology, the Lurgi Demonstration Project. A DDP was submitted for this project in February of 1981, but the project was placed on hold in June 1981 because cost estimates had come in much higher than expected.

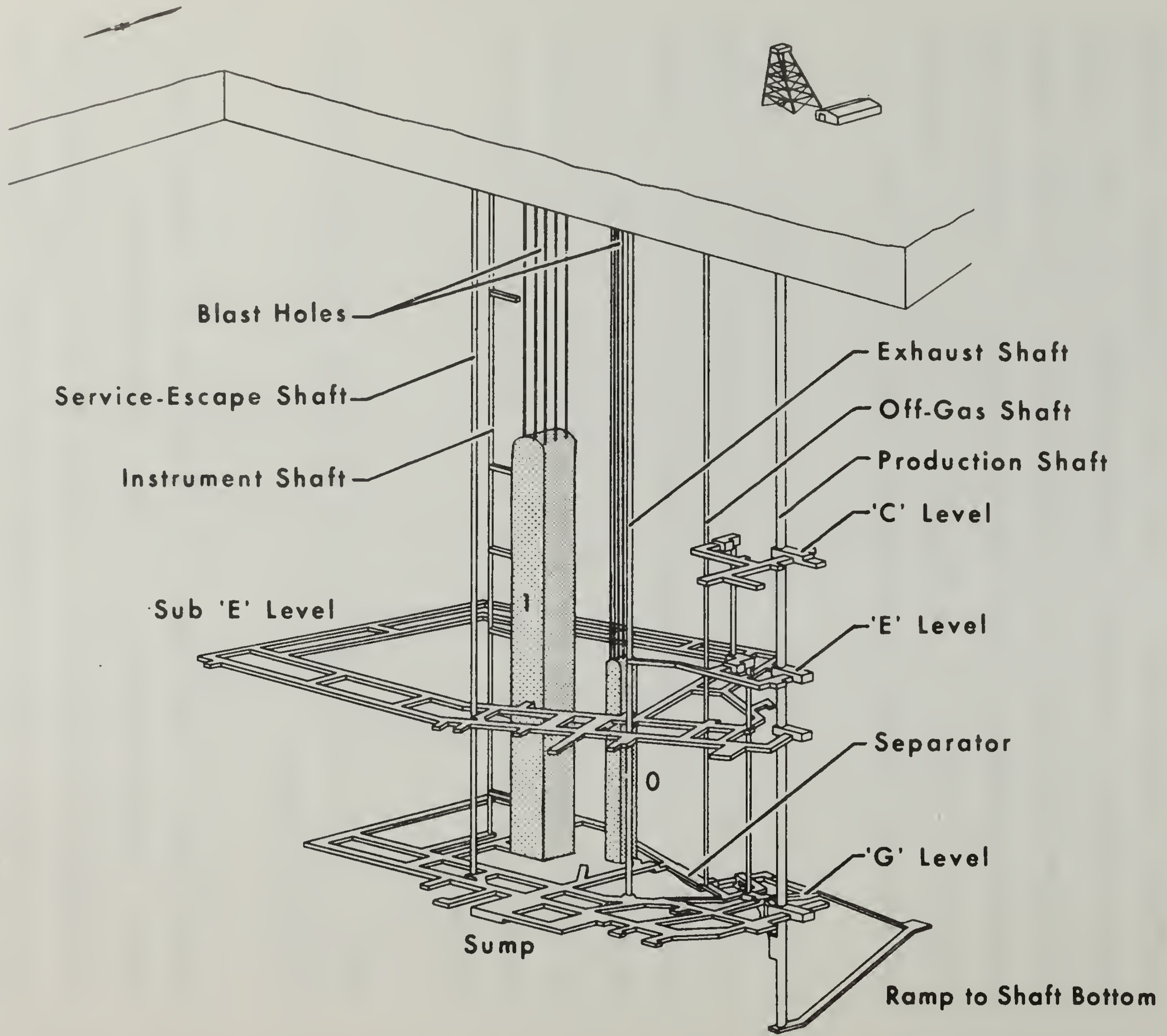


Figure 1-2-1. MIS-MDP Mine and Retort Development Plan

MDP Schedule for Retort '0' and Retort '1'

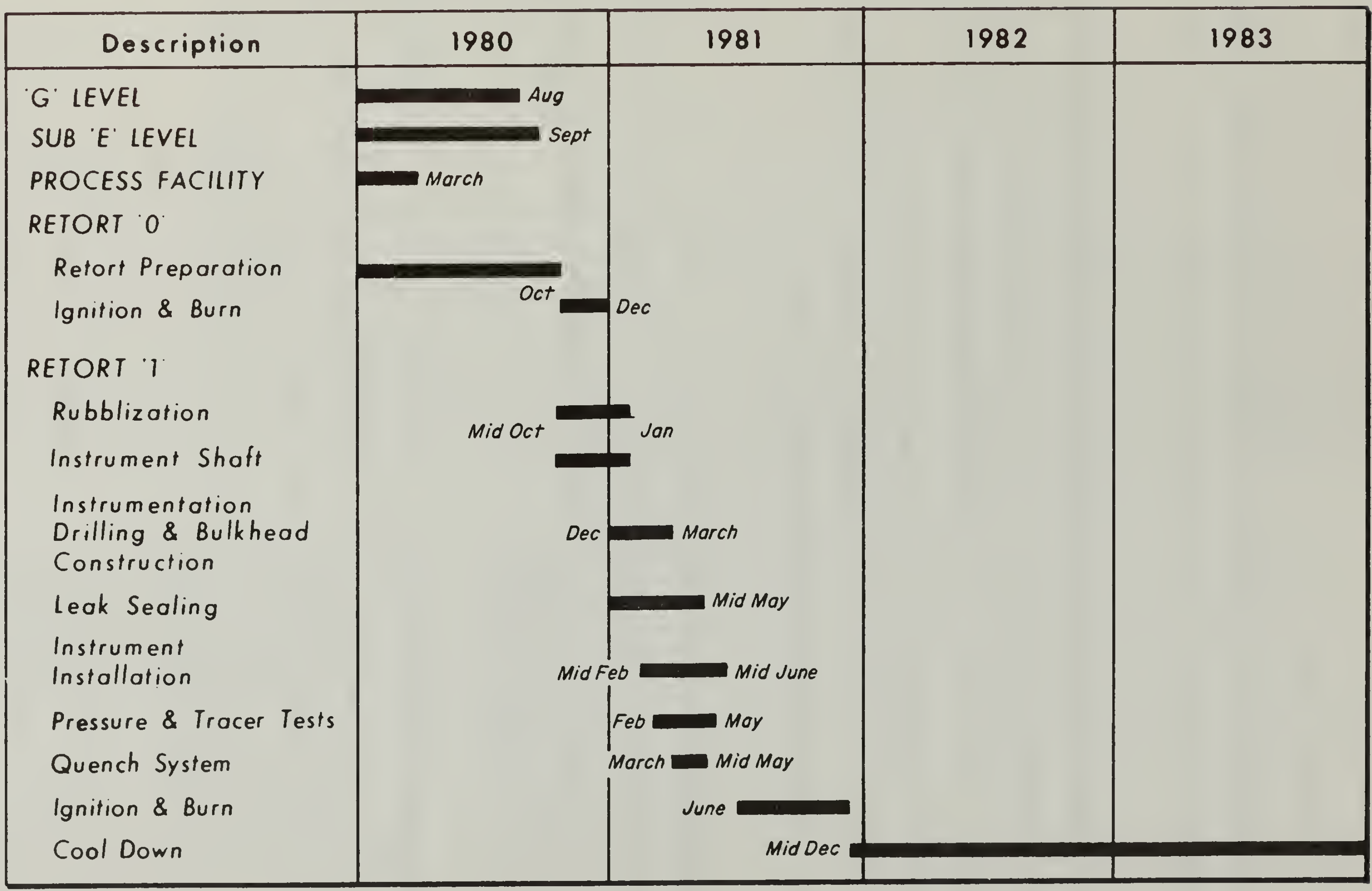


Figure 1-2-2. RBOSC MDP Schedule

TRACT ACTIVITIES, January 1981 to December 1981

The year was almost entirely devoted to preparation and burning Retort One. Table 1-2-1 summarizes the major milestones passed during the year.

The mining construction of Retort One was basically completed in March as originally scheduled. The retort was ready to burn in April. However, the first tests showed that formation leakage to the vertical shafts was unacceptable. This was an unpredictable element which took some time to rectify. The leakage was reduced to satisfactory levels (20% of first condition) by late May.

On June 3 Retort One was connected to the off-gas product drift for final testing. Retort One ignition on June 20, 1982 went quickly and retort operations proceeded smoothly except for mechanical problems with the gas treatment facility.

In addition to MIS work, two advance jobs for the Lurgi Demonstration Project were completed before that project was placed on hold. A 2,600 foot access road was built to the plant site north of the tract and six office trailers were set up on the MIS site to accommodate the advance team on Lurgi construction.

The spontaneous heating of a portion of the shale stockpile has apparently stopped. The worst hot spots were dozed into shallow piles where the material quickly cooled. The surrounding stockpile was

monitored with thermocouples and has now approached ambient temperatures.

A U.S. Bureau of Mines sponsored experiment using processed shale to grout oil shale rubble was executed on tract with good results.

All service operations systems operated satisfactorily during the year. Water management problems, which had been of concern in 1980, were resolved before the Retort One Burn.

Table 1-2-1

Tract C-a Major Milestones, 1981

	Start	Completion
Retort 1 Rubblization	July 1980	January 1981
Retort 1 Concrete Isolation Bulkheads	January 1981	February 1981
Retort 1 Surface Piping	December 1980	February 1981
Shale Stockpile Heat Monitoring Holes	February 1981	February 1981
Instrument Drilling & Installation for Retort 1	January 1981	April 1981
Retort 1 Tracer Tests	March 1981	June 1981
Retort 1 Remedial Sealing	April 1981	June 1981
Phase III Ponds	May 1981	September 1981
Retort 1 Ignition	June 1981	June 1981
Retort 1 Burn	June 1981	December 1981
Shale Grouting Test	July 1981	September 1981

Table 1-2-2

Tract C-a Major Contractors and Responsibilities

1981

Contractor	Responsibilities
Morrison-Knudsen Company (M-K)	Construction Management, Design Engineering, Quality Control, and Administrative Functions
Mine, Shaft & Tunnel (MS&T)	Mine Development, Underground Construction, Operations, and Maintenance
The Industrial Company (TIC)	General Services Contractor, Above Grade Construction for Process Facility
Construction Survey	Site Survey
White River Roustabouts	Fencing and Clearing
Corn Construction	Airstrip Overlay and Sealcoat
Star/Adair Insulation	Piping & Mechanical Insulation
Systems, Science & Software	Tracer Gas Measurement
Holleran Services	Socio Economics Studies
Rocky Mountain Refractory Service, Inc.	Refractory Repair - Incinerator
White and Sons Construction	Evaporation Ponds (Phase III)
Colorado Well Service	Burner Placement
Glenco Technology	Product Collection Drift and Separator Room Sealing
Big Red Drilling	Monitoring Holes
Rippy Construction	Lurgi Access Road

The project organization and contracting arrangements remained almost the same as in prior years. The great bulk of the work was accomplished by four entities combined into one project organization:

	Number of Employees 1981	
	January	December
Rio Blanco Oil Shale Management and Planning Process Supervision	27	17
Morrison-Knudsen Project Administration	40	22
Mine Shaft & Tunnel -- MS&T Mine Supervision and Labor	120	22
The Industrial Company -- TIC Process Craft Labor Services & Surface Construction	122	60

Other specialized contractors were called in as necessary.

Table 1-2-2 lists the major contractors and their work responsibilities at Tract C-a during 1981.

The following pages illustrate the surface configuration of the project.

Figure 1-2-3 shows the overall Tract C-a plot plan.

Figures 1-2-4 and 1-2-5 show the MDP Mine and Processing Facility Area.

Figure 1-2-6 is an aerial photograph of the MDP construction area. The Phase III Evaporation Ponds (identified by the arrow) are the primary visible major additions in 1981.

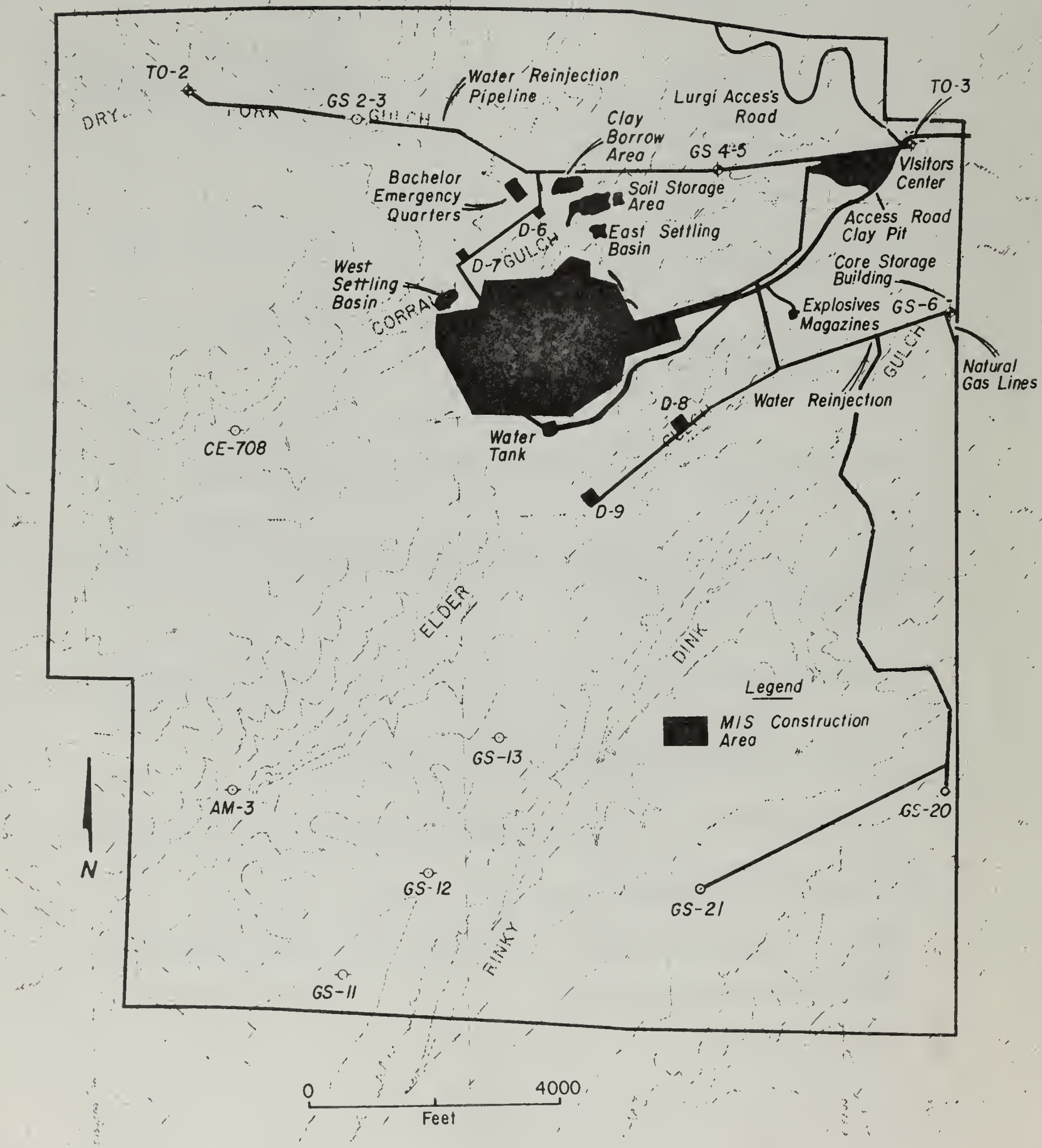


Figure 1-2-3. Tract C-a Plot Plan

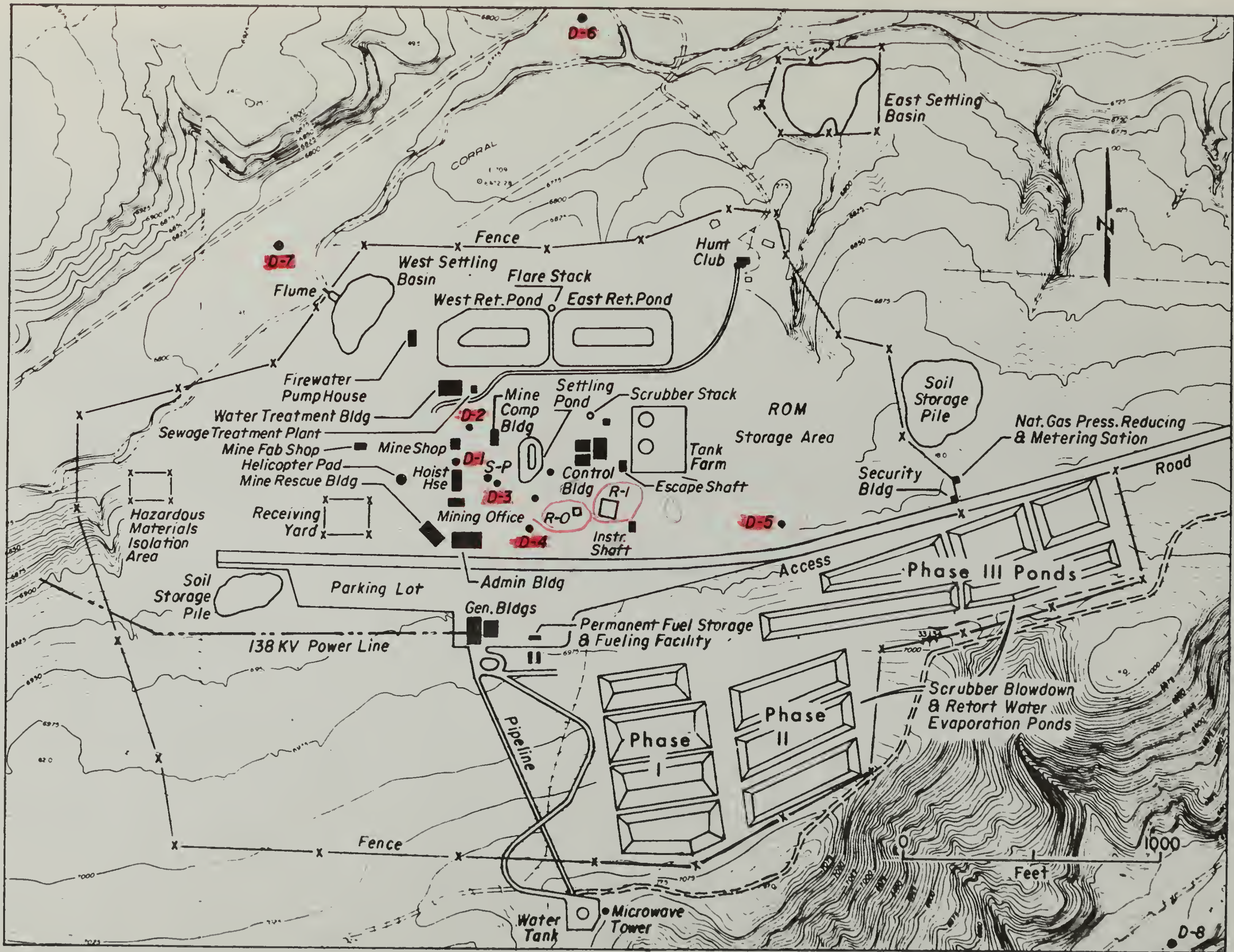
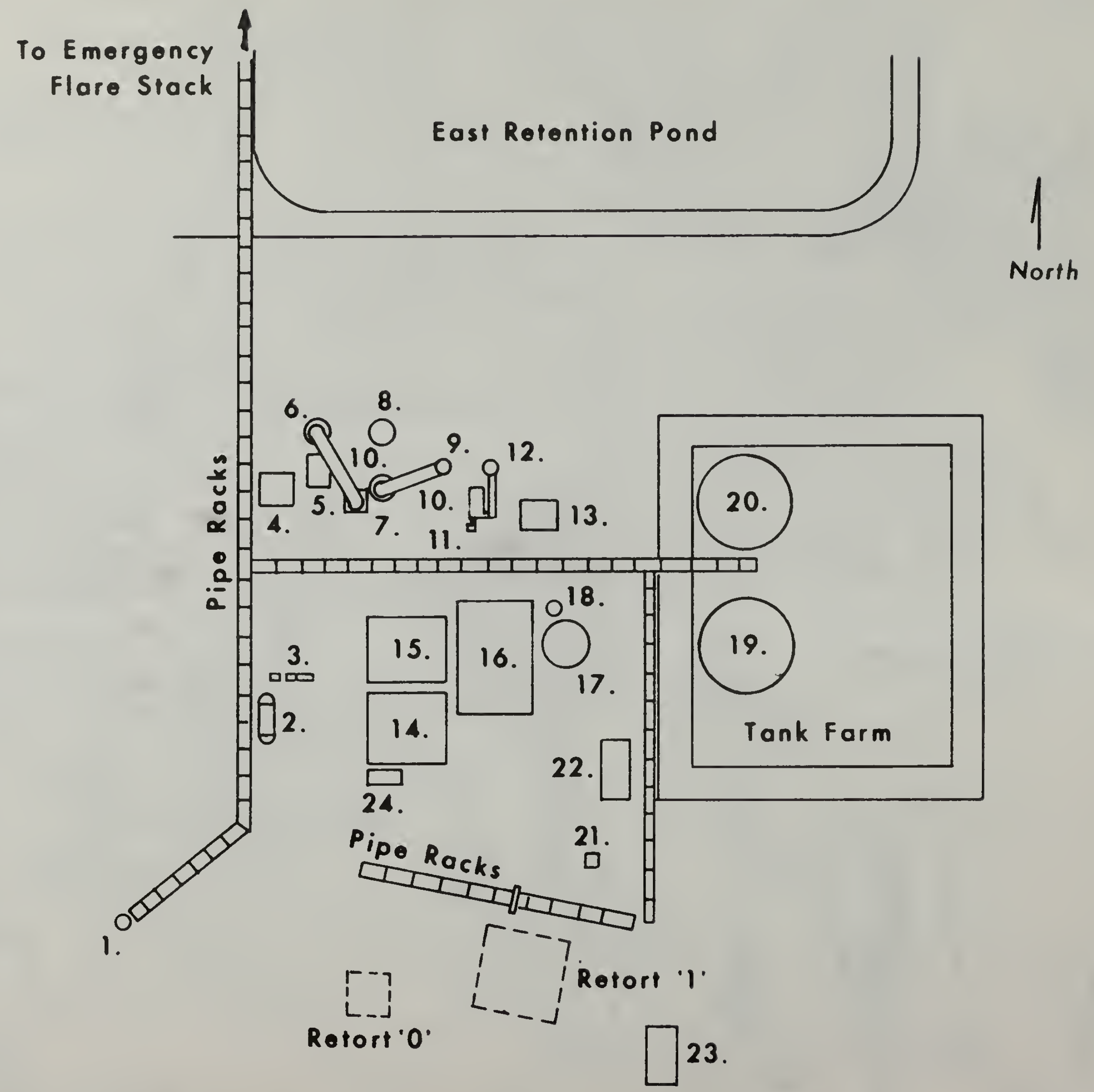


Figure 1-2-4. MIS Construction Area, December 1981

LOCATE



Legend

1. Retort Offgas Shaft
2. Knockout Drum
3. Retort Offgas Compressors
4. Housing for Incinerator Combustion Air Blower
5. Retort Offgas Incinerator
6 Quench Tower
7. Retort Offgas Venturi Scrubber
8. Soda Ash Storage Tank
9. Retort Offgas Scrubber Stack
10. Ductwork
11. Steam Generator
12. Steam Generator Stack
13. Plant & Instrument Air Compressor Building
14. Motor Control Center Building
15. Control Room Building
16. Boiler Water Treatment Building
17. Treated Water Storage Tank
18. Water Collection Tank
19. Sour Water Storage Tank
20. Raw Oil Storage Tank
21. Retort Air Compressor
22. Escape Shaft
23. Instrumentation Shaft
24. 1000 KW Generator

Figure 1-2-5. MIS Processing Facility Plot Plan

Figure 1-2-6. MDP Area Overview Looking S.E., November, 1981.

2.3 SOCIOECONOMIC ACTIVITIES

Reports of socioeconomic plans and activities related to tract development are not required by the lease and are not included in the body of this report. However, RBOSC recognizes the need to identity and resolve socioeconomic problems relating to the development of Tract C-a.

As a step in approaching resolution of some of those socioeconomic problems, in May of 1981, RBOSC established a Community Relations office in Meeker, Colorado to work with the Western Slope communities and help prepare for growth related to the Lurgi Demonstration Project. However the growth did not occur because of the delay in the Lurgi Demonstration Project.

As various construction tasks related to MIS were completed during 1981, the number of employees working on Tract C-a ranged from a high of 338 in January to 136 at the end of year.(See Table 1-2-3)

Historically approximately 79 percent of Tract C-a employees have lived in the Rifle area, 17 percent in Meeker, and 4 percent in Rangely. These percentages held essentially constant through the workforce reduction.

Since each of these communities is more than 50 miles from Tract C-a, it was often necessary for key personnel to stay overnight at the Bachelor Emergency Quarters on Tract (24 Beds). Maintenance crews working overtime on equipment repairs also used the facility extensively.

Table 1-2-3

MAXIMUM MONTHLY WORKFORCE, Tract C-a

1981

Month	Maximum Workforce
January	338
February	338
March	313
April	295
May	272
June	235
July	215
August	193
September	170
October	152
November	145
December	136

2.3 SOCIOECONOMIC ACTIVITIES (Cont.)

A. Transportation Transportation for Tract employees was provided from Rifle, Meeker, and Rangely with buses and vans. At the beginning of the year, three 43-passenger buses operated from Rifle and one from Meeker. At year-end two buses were being utilized on day shift from Rifle, with all other shifts from all three towns travelling in 12-passenger vans.

B. Socioeconomic Planning Holleran Services, Inc. completed the preliminary housing study as a part of the long range impact mitigation planning effort related to the Lurgi Demonstration Project. With changes in the Tract development schedule and profile, Holleran's contract was terminated in July, 1981. Additional impact mitigation planning is being conducted by and managed through the RBOSC Community Relations office in Meeker.

One of the major efforts to define the appropriate role of industry and local government is through the Cumulative Impact Task Force. The CITF is a forum within which the State, local government, and industry work to develop a common methodology for addressing socioeconomic impact problems. The final product of this project will be developed into a computer model that will be available for all members of the Task Force.

In preparation for the now-postponed Lurgi Demonstration Project, RBOSC purchased a 107-acre tract of land (Ute Terrace) nearly adjacent to the town of Meeker for possible development as transition housing (bachelor

SOCIOECONOMIC ACTIVITIES (Cont.)

quarters and family housing). This property acquisition will no doubt be incorporated in future housing strategies.

C. Mobile Home Park - Rangely To help stimulate construction of a mobile home park in Rangely, RBOSC in 1979 had entered into a guaranteed rental agreement with a local developer. Under the terms of that agreement RBOSC guaranteed rentals until the park reached an occupancy level of 25 mobile homes. Currently the park is fully occupied with 36 mobile homes; therefore, RBOSC's committment has terminated.

D. Tract C-a to Rangely Road In the last part of 1981, Rio Blanco County began construction of the eastern segment of the Rangely road. The 1980 Colorado General Assembly provided $2.0 million from the Oil Shale Trust Fund to start construction of the road to Rangely. The July 1, 1981 deadline for use of this money was extended to December, 1982. At the suggestion of the BLM, the eastern end of the road was rerouted down Trail Canyon and across 84 Mesa. In late September, Rio Blanco County awarded the bid for initial construction work on this road to National Construction Company of Boulder, and construction began soon thereafter. RBOSC had no participation or involvement in that construction.

2.4 REGULATORY REQUIREMENTS

Applications for State and Federal permits needed to construct the Lurgi Demonstration Project were submitted during the first quarter of 1981. Certain permit applications, such as the county Special Use Permit and the Mined Land Reclamation Permit, were withdrawn when the decision to delay the construction of the demonstration project was made. For others, such as the State Air Emissions Permit and the PSD permit, the review process was nearing completion when the decision to delay the project was rendered, and thus, it was decided to continue to pursue issuance of these permits. The State Air Emissions Permits for the Lurgi Demonstration Project were issued in July 1981. Issuance of the PSD permit has been delayed at RBOSC's request in order to extend the expiration date for the permit.

The draft NPDES Discharge Permit was issued during November, 1981. This draft permit was 1) a renewal of an existing permit for discharges from the MIS facilities plus 2) requests for new permits for the proposed additional discharges from the Lurgi demonstration facilities. RBOSC is requesting that the final permit cover only the renewal requirements for discharges from the existing MIS operations.

All other major permits and approvals for the MIS demonstration had previously been obtained.

2.5 FINANCIAL INFORMATION

The 1981 summary of expenditures by RBOSC on Tract C-a are as follows:

Table 1-2-4

Summary of Costs - 1981

($000)

MIS Development	
Site Work	636
Process Facility	402
Shaft, Hoist & Headframe	-0-
Mine Services	4,188
Drifting, Retorting	753
Operations	8,624
Managing Contractor Services	1,788
Technology Design	268
Environmental	433
Other	2,013
Total MIS Development	19,105
Administrative	3,697
Total C-a Project	$22,802

SECTION II

MINING

During 1981, the MDP mine saw very little change in configuration. The major change in plan was the indefinite deferral of Retort Two, the determination being that Retorts Zero and One would adequately assess the feasibility of Modified In-Situ Retorting for the time being.

In addition to the successful execution of the MIS demonstration plan, mining operations established confidence that underground mining and construction can be conducted in close proximity to burning retorts. Elaborate monitoring systems and alarm systems to protect personnel were proved effective. However no serious air quality problems or unsafe conditions developed.

2.2 TRACT ACTIVITIES

Most of the traditional "mining" work in the MIS program was accomplished in 1980.

During 1981, the mining effort went through two transitions, with concurrent reductions in workforce. At the beginning of the year the crew moved from mining excavation work to instrumentation drilling and construction. About the middle of the year another transition was made to pumping operations, equipment maintenance, and underground retort monitoring .

In the course of completing a wide variety of work, (some "first-of-a-kind"), a good safety record was compiled: The mine had one lost time accident in 126,636 manhours -- with the last ten months being worked without a lost time accident.

By year end the mining crew was down to 18 people -- a multi-craft group capable of maintaining all systems and performing limited ground support work or mine excavation for sample feed to the Lurgi PDU.

Table 2-2-1 is a summary of the 1981 mining milestones.

Table 2-2-1

Mining Milestones

1981

	Start	Completion
Retort 1 Rubblization	November, 1980	January, 1981
Retort 1 Instrumentation Shaft	November, 1980	January, 1981
Retort 1 Instrumentation Drilling	January, 1981	March, 1981
Retort 1 Leak Sealing and Testing	April, 1981	June, 1981
Retort 1 Instrumentation Placement	January, 1981	June, 1981
Retort 1 Burn Support Operations	June, 1981	December, 1981

MINE DESIGN

Principal elements of the approved MDP mine design were verified in operations, although some minor revisions were made to mitigate problems that arose during construction and operation of the mine.

The one area of unpredictability was formation leakage from the retorts to the mine. Leakage from Retort One occurred primarily through the instrument shaft stations. This was solved by a variety of measures including plugging the top and bottom of the instrumentation shaft and pressurizing it with boiler flue gas.

Off gas quenching and oil sampling points were changed with the redesigned systems proving quite satisfactory. More details on underground design changes relating to the process are given on page 3-1-15.

The current layout of G, Sub E, and E and C levels are shown in Figures 2-3-1, 2-3-2, and 2-3-3 respectively. The basic ventilation plan during Retort 1 burn is included on these drawings.

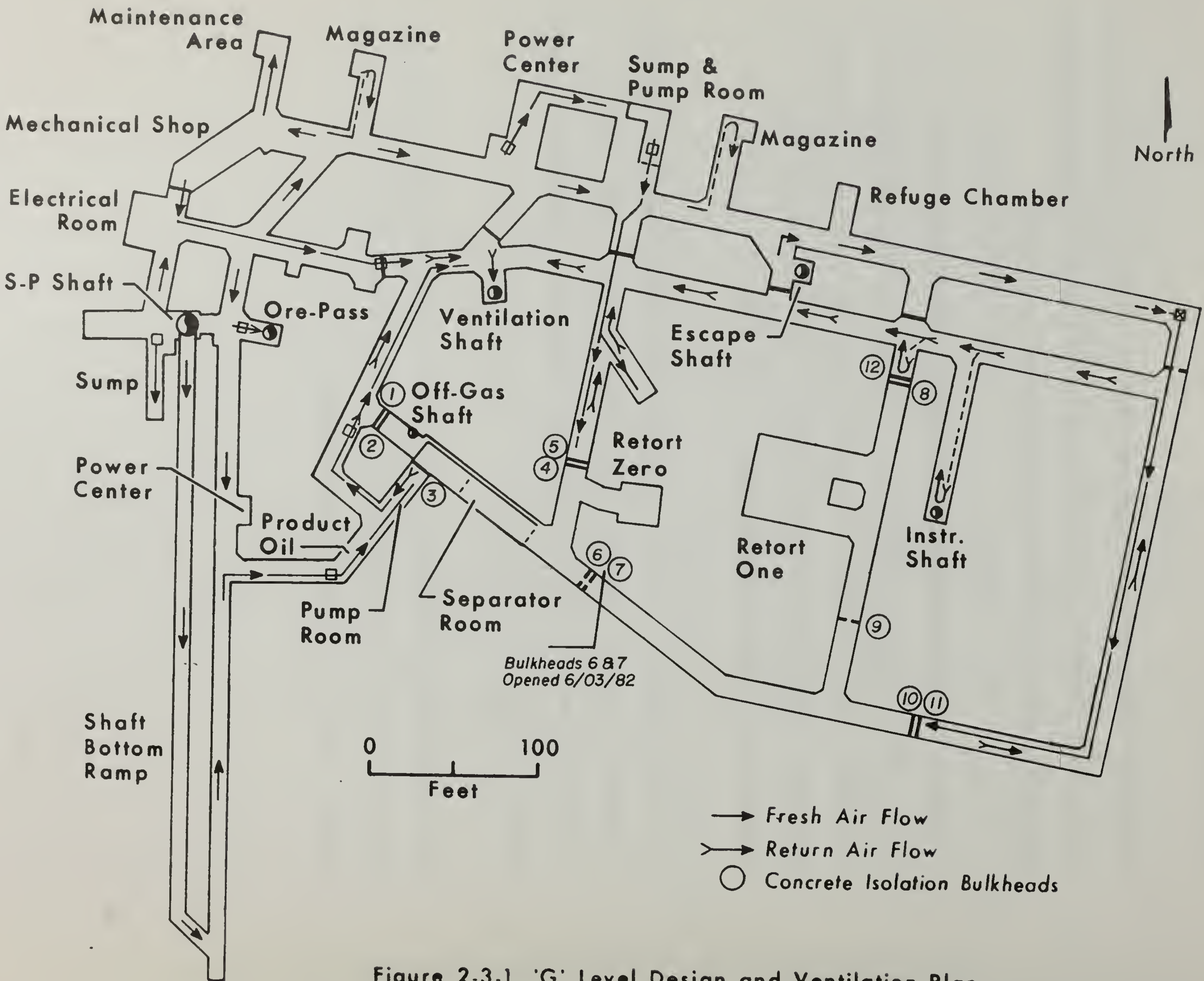


Figure 2-3-1. 'G' Level Design and Ventilation Plan

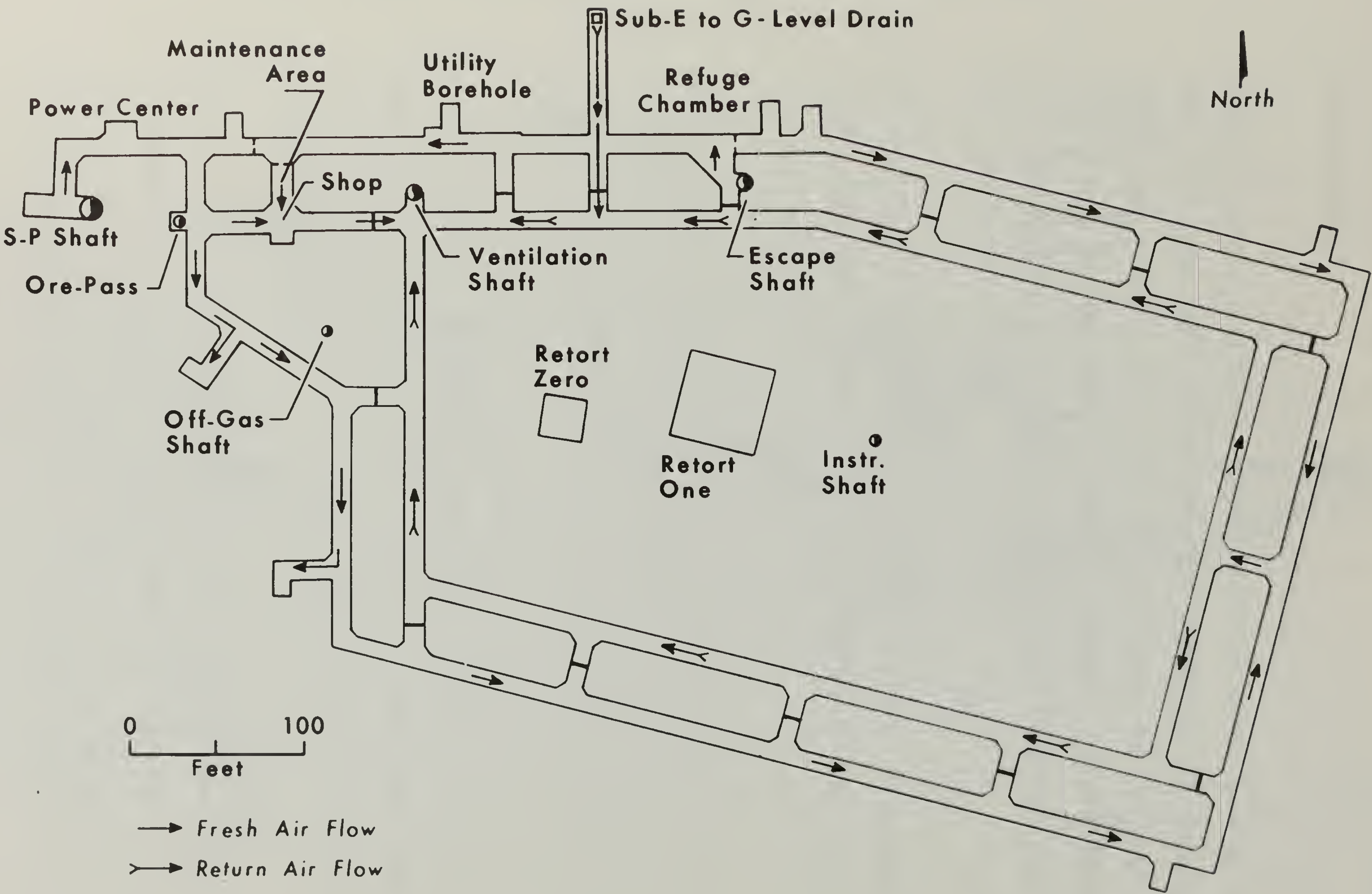


Figure 2-3-2. Sub 'E' Level Design and Ventilation Plan During Retort '1' Burn

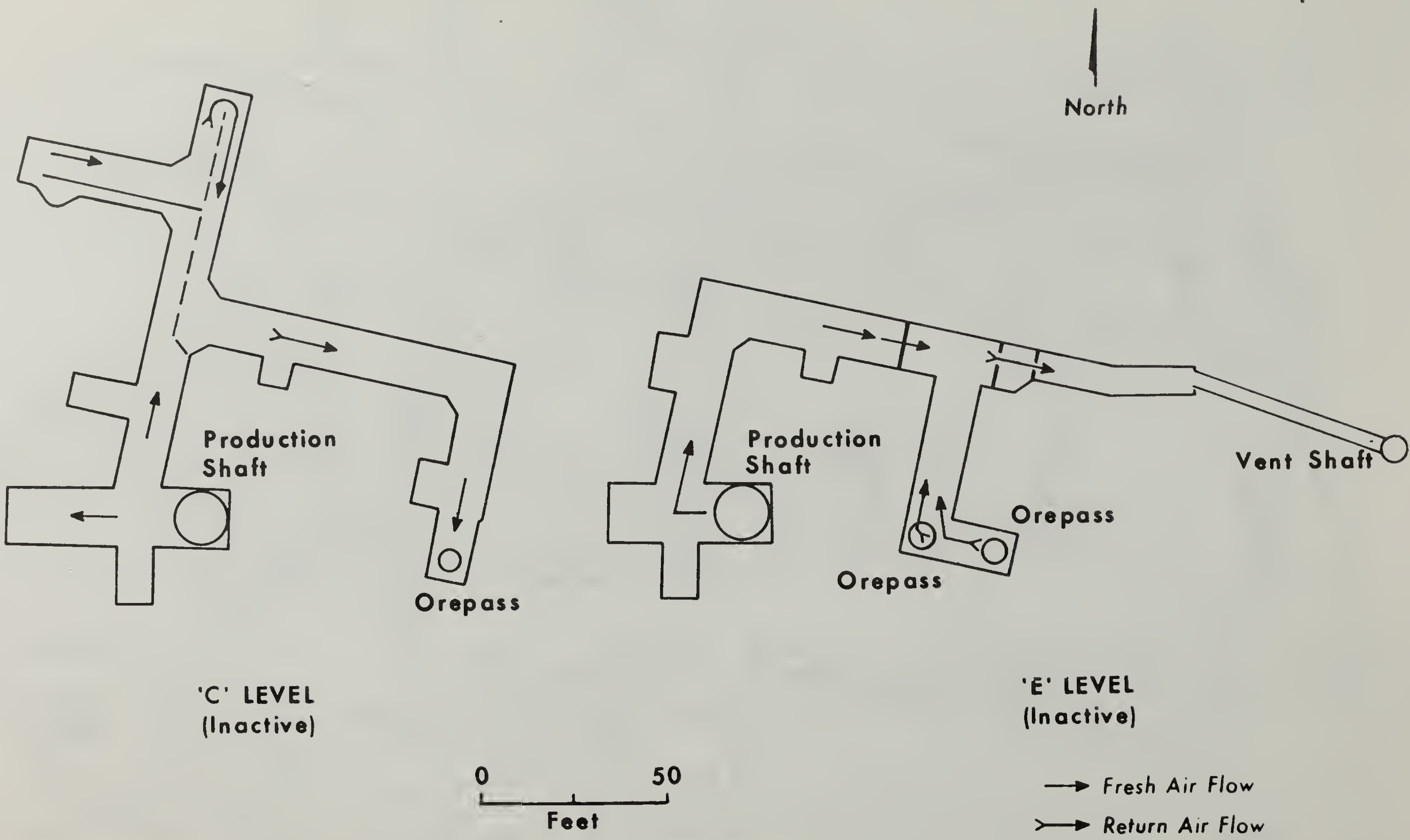


Figure 2-3-3. 'C' and 'E' Level Design and Ventilation Plan

MINE DEVELOPMENT

All primary mine excavation and mine facilities were completed during 1980. The year 1981 began with the completion of Retort One rubblization. Then came long hole drilling for placement of thermocouples in the rubble. Isolation bulkheads, remedial sealing, quench systems, and an oil sampling system were all completed before the retort was ignited in June.

Drilling to place instruments in the rubble and retort sealing proved to be two of the most challenging tasks encountered, requiring a good deal of innovation.

The only oil shale hoisted was a 350-ton sample from the "G" level ramp; this sample was used for various testing programs. Tables 2-4-1 and 2-4-2 show the quantities mined both during 1981, and the entire project.

During the burn of Retort One, the mine crew performed all underground support work; oil pumping, sampling, monitoring, ventilation dewatering pumping, plus maintenance and calibration of the extensive underground instrumentation system.

Completely apart from the MIS mine activities, the mining crew supported experimental work in grouting shale rubble with a slurry of Lurgi processed shale in water. This work was directed by Soletanche as part of a USBM supported contract on MIS retort grouting. A large pit was

excavated, lined, and filled with broken raw shale rubble. The pit was then covered with backfill and grouted under slight pressure. Some 60 days later the pit was carefully excavated to characterize the grouted mass.

Table 2-4-3 lists the major mine accomplishments in 1981. Some of these items are described in more detail under Processing.

Table 2-4-1

Material Mined During 1981

Sample G Level Ramp	350 tons
TOTAL	350 tons

Table 2-4-2

Material Mined - Total Project

	1978	1979	1980	1981	Total
Shafts & Ore Passes	11400	7250	8350	-	27000
C Level	8040	-	-	-	8040
E Level	4330	1700	220	-	6250
Sub E Level	-	-	38440	-	38440
G Level		13100	42600	-	55700
Retort 0 Rubble	-		1860	-	1860
Retort 1 Rubble	-	-	30060	-	30060
Instrument Station	-	-	3520	-	3520
Samples	-	-	425	350	775
Total	23770	22050	124675	350	171645

Table 2-4-3

Major Mine Accomplishments

1981

Accomplishment	Start	Completed
	1981	1981
Retort 1 Rubblization	November, 1980	January
Instrumentation Shaft Stations (6)	November, 1980	January
Rock Mechanics Core Drilling	December, 1980	January
Instrumentation Drilling	January	March
Retort 1 Bulkhead Construction	January	February
Instrumentation Installation	February	June
SF_6 Leak Testing	March	June
Retort 1 Leak Sealing	April	May
ROM Stockpile Temperature Monitoring	January	On-going
Install Quench Systems for Retort 1	February	May
Line 390 Feet of Service/Escape Shaft	March	April
Install Revised Abex Cage in S/E Shaft	May	May
Plugged Top and Bottom of Instrument Shaft	May	May
Remote Monitoring System for Mine Dewatering Pumps	May	July
Opened Product Collection Drift between Retort 0 and 1	June	June
Retort 1 Burn	June	December
Install Backup Quench Systems	October	November
Processed Shale Grout Trench Test	May	October

4.1 SUPPORT OPERATIONS

A. Ventilation Mine ventilation continued essentially unchanged during 1981. The mine is ventilated with an 8 foot diameter, 300 h.p. Jeffrey Fan exhausting air at a rate of 235,000 cfm. Auxiliary fans ranging from 7.5 to 60 h.p. are used to assure air flow in critical areas of the mine. Figures 2-3-1 through 2-3-3 (previous pages) show the ventilation system layout during 1981.

B. Mine Gases The mine was operated all year under the MSHA gassy mine classification. No serious problems resulted from this classification. Small amounts of methane are still being emitted on G level, but the ventilation system is adequate to dilute and disperse it. Hydrogen sulfide is found on Sub E level where it is associated with ground water. Ventilating air is maintained in sufficient quantities to keep the H_2S below the 8-hour exposure limit of 10 ppm. Monitoring for mine gases was conducted in three ways:

- Hand instrument gas checks for CH_4, H_2S, and CO were made each shift in each work place.
- A total of 5 instrument stations (M-2 system) monitored for CH_4, H_2S, CO, and O_2 at various critical points in the mine. These stations gave local alarms in case the 8-hour exposure limit was exceeded. This same data was transmitted to the surface computer for data logging and monitoring.
- The total mine exhaust was also monitored by continuous CH_4 and CO instruments (the M-3 system).

Retort gases did not cause any problems since Retort One operated under a vacuum so that any leakage was into the retort rather than into the mine. System reliability was good--no unplanned pressure conditions

4.1 Support Operations (Cont.)

occurred. System changes and some limited pressure operations were conducted with workers out of the mine. No exposure of miners to retort gases was reported.

C. Ground Control The mine roof is stable and the split set rock bolts are working well. Some remedial bolting has been done with galvanized split set bolts where corrosion of the original bolts has been detected. A few steel sets were placed on Sub E level in the return air course near the Service/Escape Shaft to control an area where the roof was thin-bedded and highly fractured. This area is shown on Figure 2.4.1 along with steel sets placed in 1980. Figure 2.4.3 shows the location of previously placed steel sets on E level.

Some caving of the roof above the retort was detected prior to and after the ignition of the retort. Slight movements up to 30 feet above the retort are suspected. This caving caused no problems in retort operation.

D. Mine Drainage Water flow into the mine decreased from 1400 gpm in January to 1050 gpm in November. In December the mine inflow increased to 1200 gpm when two surface dewatering wells were decommissioned. Over 90% of the mine water inflow is captured by drift long holes on Sub E level. The dewatering system effectively rendered Retort 1 dry, with

less than 12 gpm of ground water flowing into the retorts (both Zero and One) before ignition. The pumping system has been adapted to surface monitoring and control instrumentation, eliminating the need for night shift operators underground.

E. Mine Power No changes have been made in the two 4160V mine feeder systems. The 1000 kw emergency generator functioned very well in restoring main ventilation automatically when power supply interruptions developed (two cases during '81). The 2500 kw standby generator also proved reliable. This generator starts automatically upon powerline failure but requires an electrician to switch on to the bus bar and distribute the load. Shift electricians were available on a few minutes notice throughout the burn.

F. Retort Facilities The retort product collection system functioned as designed. The Sundyne pumps performed better than anticipated, probably because of the absence of entrained grit in the oil. The retort instrumentation system worked well except for the loss of thermocouples as the flame front passed them. The reliability of the mine air quality monitors improved during the Retort One burn, but more discriminating sensors would have prevented some false alarms.

G. Geology No additional mapping was done during the year. Figures 2-4-1, 2-4-2, and 2-4-3 show the general orientation of geologic structural features in the mine.

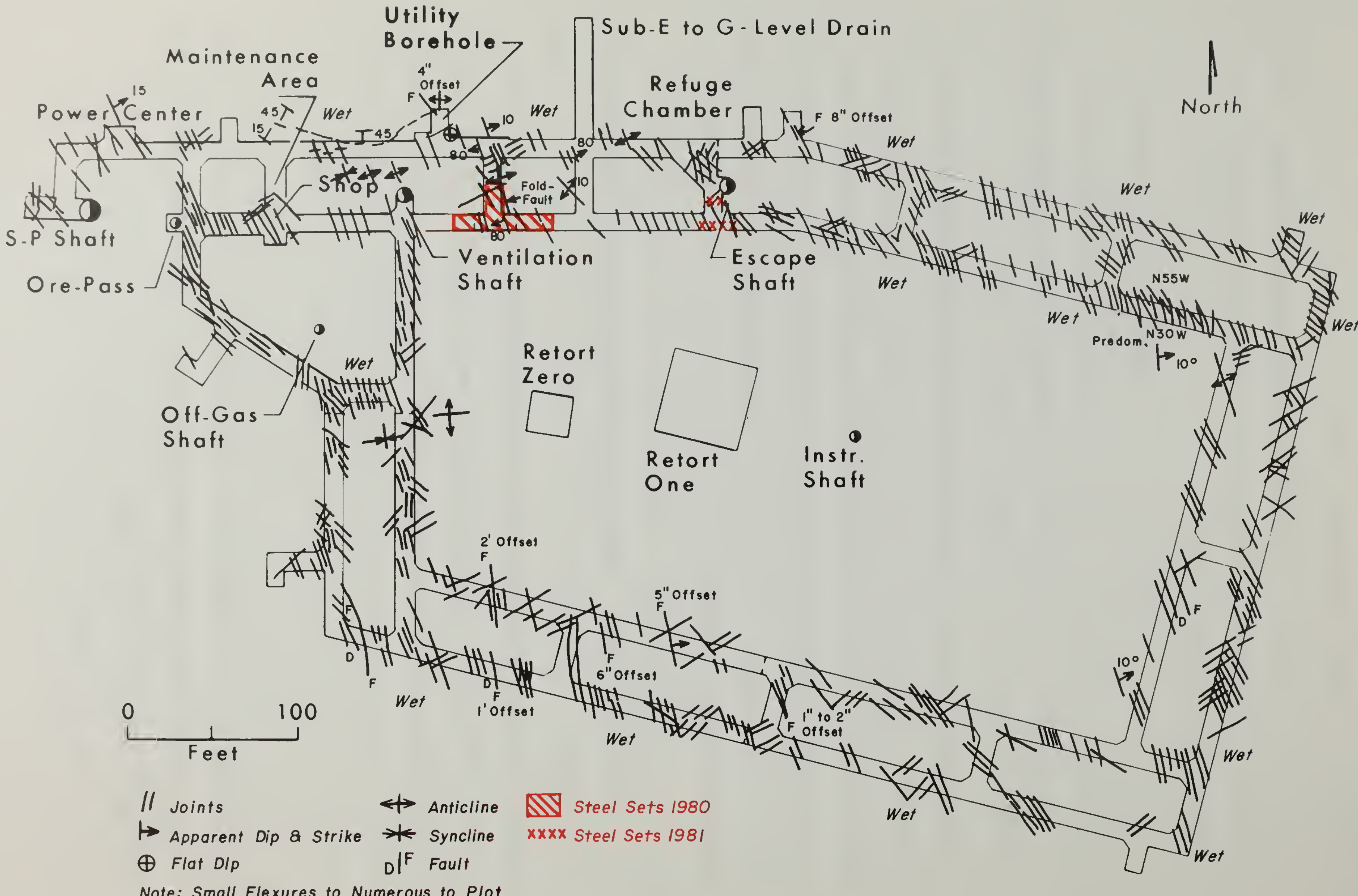


Figure 2-4-1. Sub 'E' Level Ground Control and Geologic Structural Features

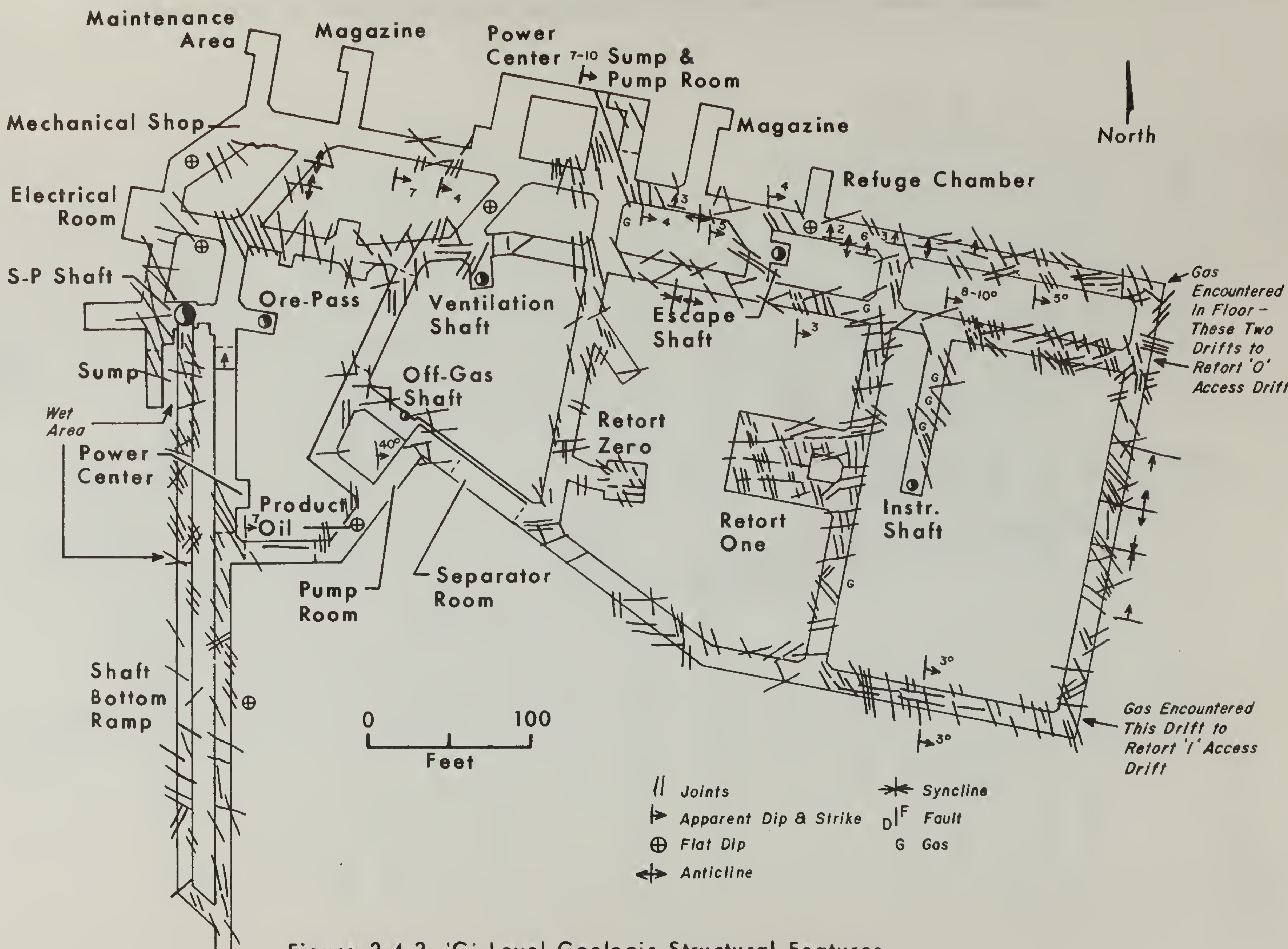


Figure 2-4-2. 'G' Level Geologic Structural Features

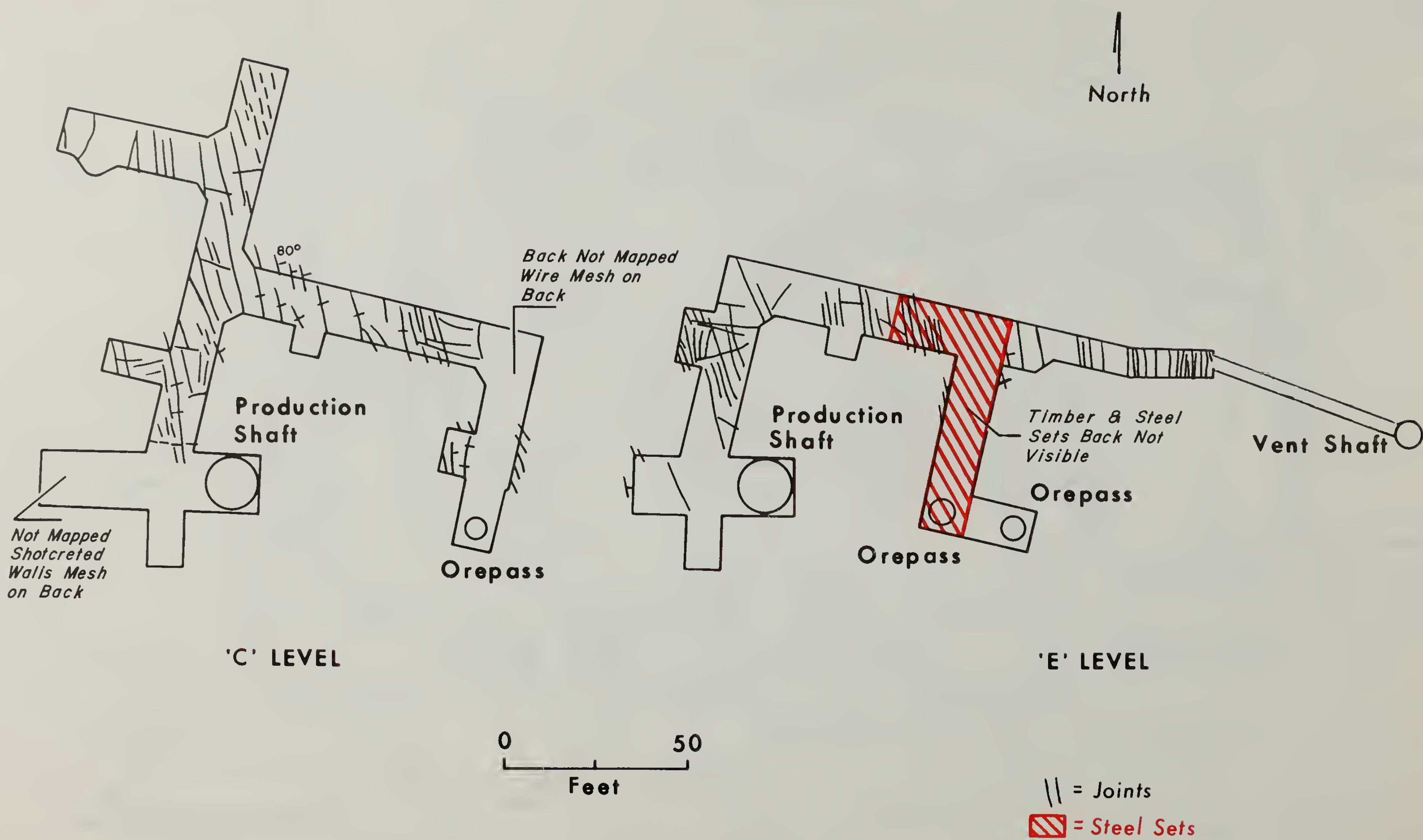


Figure 2-4-3. 'C' and 'E' Level Ground Control and Geologic Structural Features

4.1 Support Operations (Cont.)

H. Connection of Retorts On June 3, 1981, the bulkheads (#6 and #7) isolating Retort Zero from the Retort One Product Drift were opened and a crew wearing oxygen breathing apparatus inspected the separator drift (refer to Figure 2-3-1). To maintain safe conditions Retort Zero was under nitrogen purge and the retort suction blowers were drawing a slight fresh airflow into the separator room. The crew found:

- The Separator Room in good condition.
- Product drift from Retort Zero caved. Time of the cave is uncertain but it probably occurred near the end of the burn or after.
- Clear water in the separator, no oil trapped in the system.
- Carbon-like deposits on most of the walls and roof.
- Original quench nozzles plugged by scale deposits.

The crew then retreated to the external bulkheads of the Retort One product system and sealed up the manhole covers. This entire operation was completed in three hours, thus reflecting the careful planning and precautions taken to avoid exposure of crews to toxic off-gas, oxygen deficient atmosphere, or explosion hazards.

Figure 2-4-4 shows two members of the team inspecting the separator room. Figure 2-4-5 shows the caving observed in the Retort Zero product drift.

Figure 2-4-4. Inspection of Separator Room
Team wearing oxygen breathing apparatus found separator room in good condition. Clear water behind sediment dam shows in foreground. Looking NW

Figure 2-4-5. Caving of Retort Zero Entry
Inspection team found entry to Retort Zero caved out to junction with Product Drift.

4.2 Mine Safety and Health

A. Mine Safety Mine safety performance was much improved in 1981. The mine had one lost time injury (4 days charged) for a cumulative frequency of 1.58 for the year (Lost time accidents per 200,000 manhours). The reduction in accidents was due in part to reduction in extraction mining (drilling, blasting, scaling and ground support). However, many new types of construction and operations were undertaken safely. A smaller, more seasoned work force plus increased emphasis on supervisory skills, job safety analysis and training were all important factors in the improved safety record.

B. Mine Rescue One mine rescue team was on site at all times during the burn. Backup teams were on call at two hours notice. During critical periods (such as ignition) a second team was kept in BEQ housing near the site. The mine rescue program included on-going training of at least 4 hours per month to assure the competence of individual team members in working under oxygen.

Mine rescue teams were used to reenter the mine following planned evacuations for blasting or for changed retort operating conditions. This provided training opportunities and verified underground conditions before men returned underground. However, in no case did this procedure show a need to use such elaborate precautions in the future.

C. Mine Emergency Emergency procedures have been developed for all foreseeable mine disaster conditions. All mine personnel have been

trained in these procedures and are being retrained as required. The Mine Emergency Procedures Manual is a compilation of all the procedures, complete with checklists and reference materials which could be useful during an emergency.

D. Inspections All required mine and equipment inspections were made on predetermined schedules. Hoist system inspections and ventilation survey inspections were completed every week during 1981.

Outside inspections were conducted by:

- Mine Safety & Health Administration (MSHA)
- Travelers Insurance
- Safety Audit Committee -- Gulf Oil Corporation

No significant mine safety problems were found during these outside inspections. Minor infractions were corrected promptly.

E. Industrial Hygiene Program The principal addition to programs already in place were measures to avoid prolonged skin contact with shale oil or retort water. A second objective was to eliminate the possibility of retort products from being carried to the workers residences on shoes or soiled clothing.

Change rooms were provided for all mining personnel during the construction program. Almost all the contract mine workers routinely shower following every shift, and normally do not wear any of their work clothing home.

As an additional precaution, those underground workers with a potential of routinely coming in contact with shale oil and/or retort water were incorporated in the Plant Industrial Hygiene Program. In addition to showering after each day's work, these men were provided freshly laundered clothes each day. This covered men working in the product pump room and in the retort sampling system.

All other individuals were instructed to wash their skin promptly and have their clothing laundered in case of accidental contact with retort products.

A source of warm wash water was provided to the project pump room to facilitate rapid wash off of raw shale oil.

SECTION III

PROCESSING

INTRODUCTION

The Retort Zero burn was concluded in December, 1980 and retort cool-down proceeded throughout 1981. Recycling of sour water through Retort Zero for approximately two months may have helped accelerate the cooling of the retort.

Activities for the first six months of 1981 concentrated on completion of piping and instrumentation for Retort One and modifications to the plant to correct problems identified during the Retort Zero burn.

Retort One was ignited on June 21, 1981. The burn period lasted 176 days--ending on December 14, 1981. Excluding periods of air outages, the overall front advance rate was about 3 feet per day.

The ignition scheme developed by RBOSC proved successful; a commercial scale ignition system was used to ignite the retort in less than 28 hours.

Total production from Retort One was 24,444 barrels which is 68% of the Fischer Assay content of the shale rubble available for retorting.

1.1 SCHEDULE AND MILESTONES

Figure 3-1-1 summarizes the timing of construction and operations for both Retort Zero and Retort One. Retort One rubblization proceeded in parallel with the Retort Zero burn and was completed in January, 1981. Retort One pre-burn tests were carried out April through May and the Retort was ignited on June 21.

One item of particular significance on this chart is the overlap between the Retort Zero burn and the Retort One rubblization. This verified the feasibility of conducting mining and retorting operations simultaneously.

Table 3-2-1 lists more details on the above-ground processing activities completed during the year. Underground activities are shown in Table 2-2-1 in the mining section. Additional discussion on these design changes follows in sub-chapter 1.2. Photos of the revised equipment and facilities are shown as figures 3-1-2 through 3-1-7.

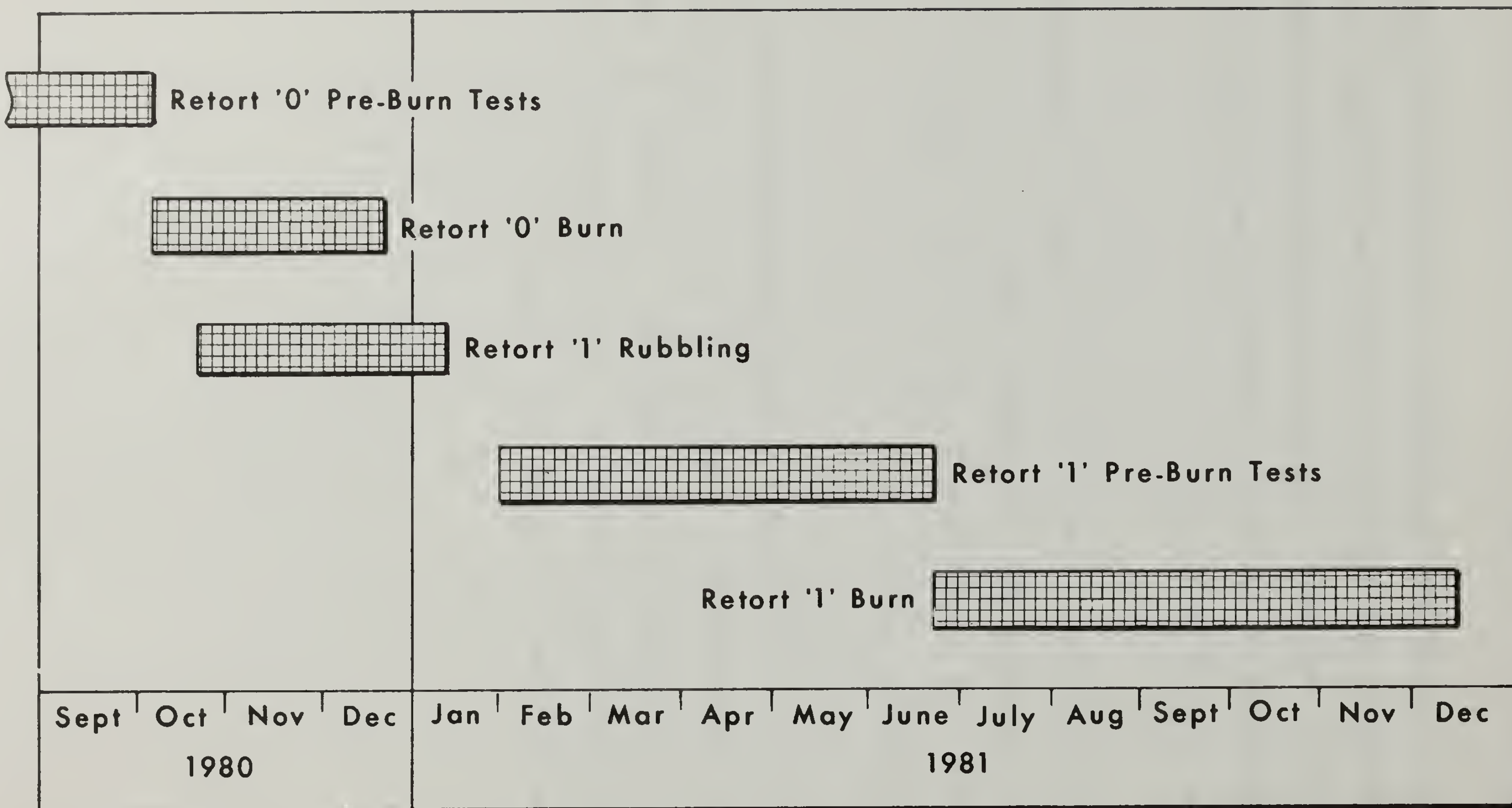


Figure 3-1-1. Timing of In-Situ Experiments

1.2 MAJOR DESIGN CHANGES - SURFACE

A. Remedial Work While the general plant and control systems worked well during Retort Zero, a number of design modifications in the process plant were implemented to improve performance during the Retort One burn. The major problems and remedial actions were:

- The backup suction blowers (C102 B&C) had exhibited some tendency to overload and shut down during Retort Zero. The piping was revamped to correct gas flow problems by elimination of short radius elbows and streamlining the suction and discharge piping. A motor current control system was installed to prevent compressor shutdown due to overload.

- An incident during Retort Zero had indicated potential safety problems with oxygen building up in the recycle loop after a sudden diversion of the off gas flow from the incinerator scrubber circuit to the flare. This was corrected by:

  1) Increasing the water volume in the D-110 water seal to reduce chances of the water seal blowing out.
  2) Establishing a fail safe level control on the water seal.
  3) Installing a 36" check valve in the off-gas line to the incinerator to eliminate the possibility of reverse air flow from the incinerator.

- Some difficulties in measuring off gas flows and maintaining gas analysis equipment were solved by:

  1) Adding an alternate F104 A meter to improve reliability of the retort off-gas measurement.
  2) Relocating the off-gas analyzer house near the off-gas collar and completely revamping the entire sample conditioning system to help mitigate problems with liquids infiltrating the gas analyzers.

- Water management had become a concern in that the Retort Zero experience indicated that the East pond, (collector for processing, plant drainage and operating spills), the scrubber blowdown ponds and the sour water ponds could all possibly be overfilled by the end of Retort One burn. These problems were dealt with by implementing a combination of measures:

  1) Reducing East pond inflows and installing a system to utilize East pond water as quench water to the incinerator and cooling water to the E-111 recycle gas cooler. This system maintained the East pond water

Table 3-2-1
Major Process Accomplishments and Milestones
1981

Accomplishments	Start/1981	Complete/1981
• Retort Zero cool-down and sour water quench phase.	January	April
• Surface piping for Retort One Ignition system.	January	March
• Installed four burner sleeves.	February	February
• Above ground burner testing.	February	March
• Modification to the D-110 seal drum.	February	March
• C-102 B/C suction compressor piping revisions.	February	March
• Alternate off-gas meter run.	February	March
• Installation of inert flue gas blower system	March	May
• Flare Seal system modifications.	April	May
• Revamped on-stream analyzer system.	April	June
• Repaired Scrubber Stack liner.	April	May
• Design and installation of Retort One control scheme.	May	June
• Installed and tested downhole burner.	May	May
• Operated suction blowers & inert gas system during underground operations connecting Retort One to the product drift system.	June 3	June 3
• Conducted leak rate testing and tracer work.	April	June
• Process water system revamped for process water supply from East Pond.	May	June
• Retort One ignited	June 21	June 22
• Retort One burn terminated	December 14	December 14

inventory under complete control throughout the burn.

2) Reduction of sour water inflows due to plant and underground operations. The principal measures were the utilization of sour water recycle for seal water on the product pumps and the elimination of excess underground off gas quench water by installation of retractable quench spray bars.

3) Additional pond capacity was constructed (see 1.2.5).

- Expansion joints on the cross-over duct from the incinerator to the scrubber were reworked twice, once before the Retort One ignition and once during the burn. This area was an unsatisfactory design.

B. New Features for Retort One In addition to correcting problems identified in Retort Zero, a number of new concepts were introduced and proved for Retort One operation. The underground leakage around Retort One required that the retort be operated under enough vacuum to prevent toxic gases from invading the mine. Vacuum had to be limited to prevent buildup of excessive oxygen in the off gas stream. The major design and construction efforts were:

- Installation of multiple downhole burners with all associated piping and ignition control systems.

- Provision of an inert gas system to pressurize the instrument shaft at a slightly positive pressure with respect to the top of the retort, thus preventing retort gas leakage from the retort to the instrument shaft. This was accomplished by installing a blower to draw boiler flue gas from the stack and deliver it through a pipe system to the shaft. Pressure was set to be slightly positive with respect to the retort.

- Provision of automatic control to maintain the retort top at a constant slightly negative pressure with respect to the mine. The control scheme was designed utilizing a cascade control loop, as determined by pressure drop across the retort at a set flow point. The revised control system was effective in very smoothly maintaining the retort under a vacuum throughout the burn. A second control loop effectively controlled the instrument shaft pressure slightly positive with respect to the retort top pressure.

Pictures of the new surface construction, installations and major design modifications and other points of interest are shown in Figures 3-1-2 through 3-1-7.

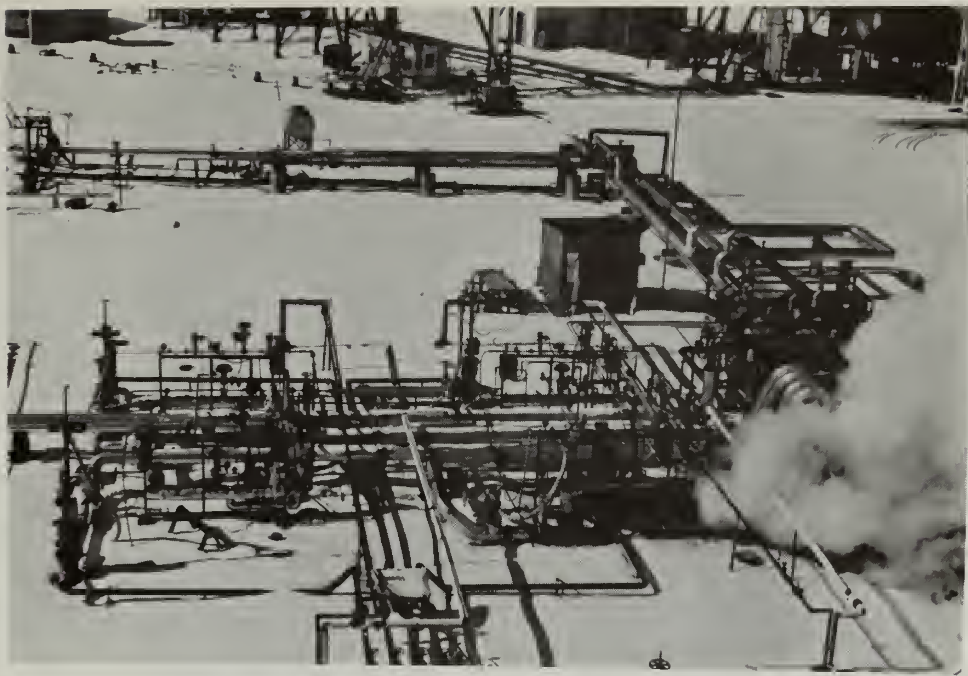


Figure 3-1-2. Piping Layout for Retort One.

Figure 3-1-3. Streamlined Piping for the C-102 Auxilliary Suction Blowers.

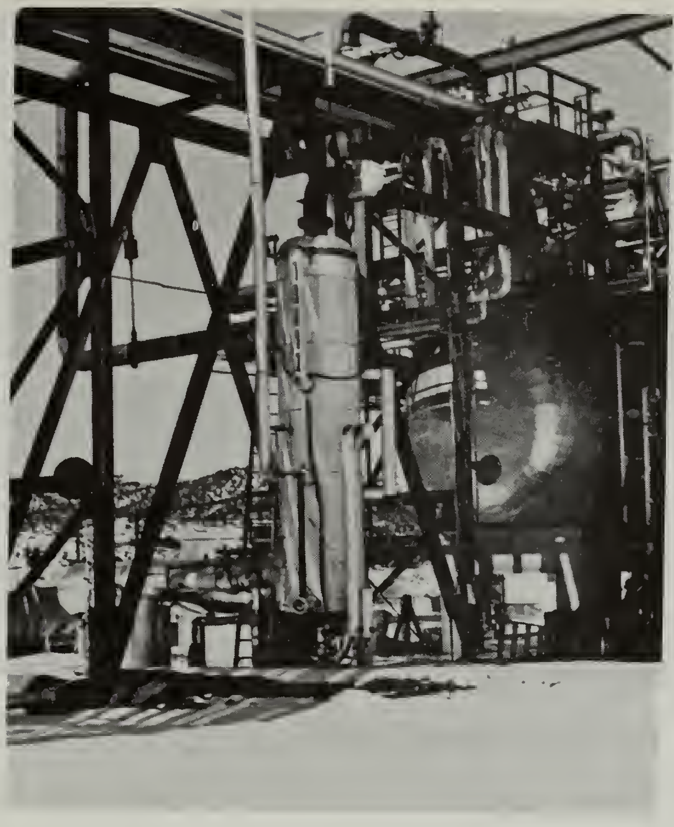


Figure 3-1-4. Modified D-110 Water Seal

Figure 3-1-5. New Location of the Off-Gas Analyzer Building

Figure 3-1-6. New Inert Gas Blower

Figure 3-1-7. Expansion Joints Between the Incinerator and the Scrubber

1.3 UNDERGROUND PROCESS INSTRUMENTATION INSTALLATIONS

A number of underground installations and modifications were made in relation to retort operations and monitoring requirements. Most of this work was performed by mining personnel but is described here for better integration with processing concepts.

A. Retort One Instrument Packages The Retort One rubble was extensively instrumented for temperature and pressure measurements. During 1980, an 8 ft. diameter shaft was drilled about 50 feet east of the Retort One east wall. Six stations were excavated to within 20 feet of the retort. From these stations thermocouples and pressure taps were placed directly into Retort One rubble, providing for detailed measurements of conditions inside the retort itself.

Altogether, some 166 thermocouples were grouped in the following arrays: 9 borehole thermocouples to measure ignition progress, 3 horizontal arrays consisting of 35 thermocouples each, an east wall vertical array with 19 thermocouples, a west or back wall vertical array with 9 thermocouples, and a bottom rubble exit array with 24 thermocouples. (The rubble exit array thermocouples were a late design change to provide a picture of the rubble exit temperature profile near the end of the burn.) Instrumentation drilling and installation proved to be one of the more challenging tasks encountered.Figure 3-1-8 shows the the thermocouple locations.

Retort pressure drop was monitored by an array of pressure taps spaced some 20 feet apart along the east side of the retort. All pressure transmitter and thermocouple signals were relayed to the surface and interfaced with the process computer data acquisition system.

A rock mechanics package completed retort instrumentation. This package consisted of an array of 10 extensometers placed in the roof of the retort to measure rock movement during and after ignition. In addition, 12 pillar thermocouples plus 7 instrument shaft thermocouples were installed to measure temperature rise in the wall of the retort and instrument shaft as the burn front advanced down the retort.

The Mine Environment Monitoring System established for Retort Zero was refined somewhat. This system (called M-2) continuously monitored the CH_4, CO, H_2S, and O_2 content of the mine air at five locations. The total mine exhaust was monitored by the M-3 system, which also measured CH_4, CO, and O_2. All these measurements were displayed on consoles at surface <u>and</u> compared to alarm set-points by the process computer.

The computer system provided immediate access to process data including flow rates, temperatures, pressures, and compositions of feed and product streams, and in the case of Retort One, temperatures and pressures within the shale rubble itself.

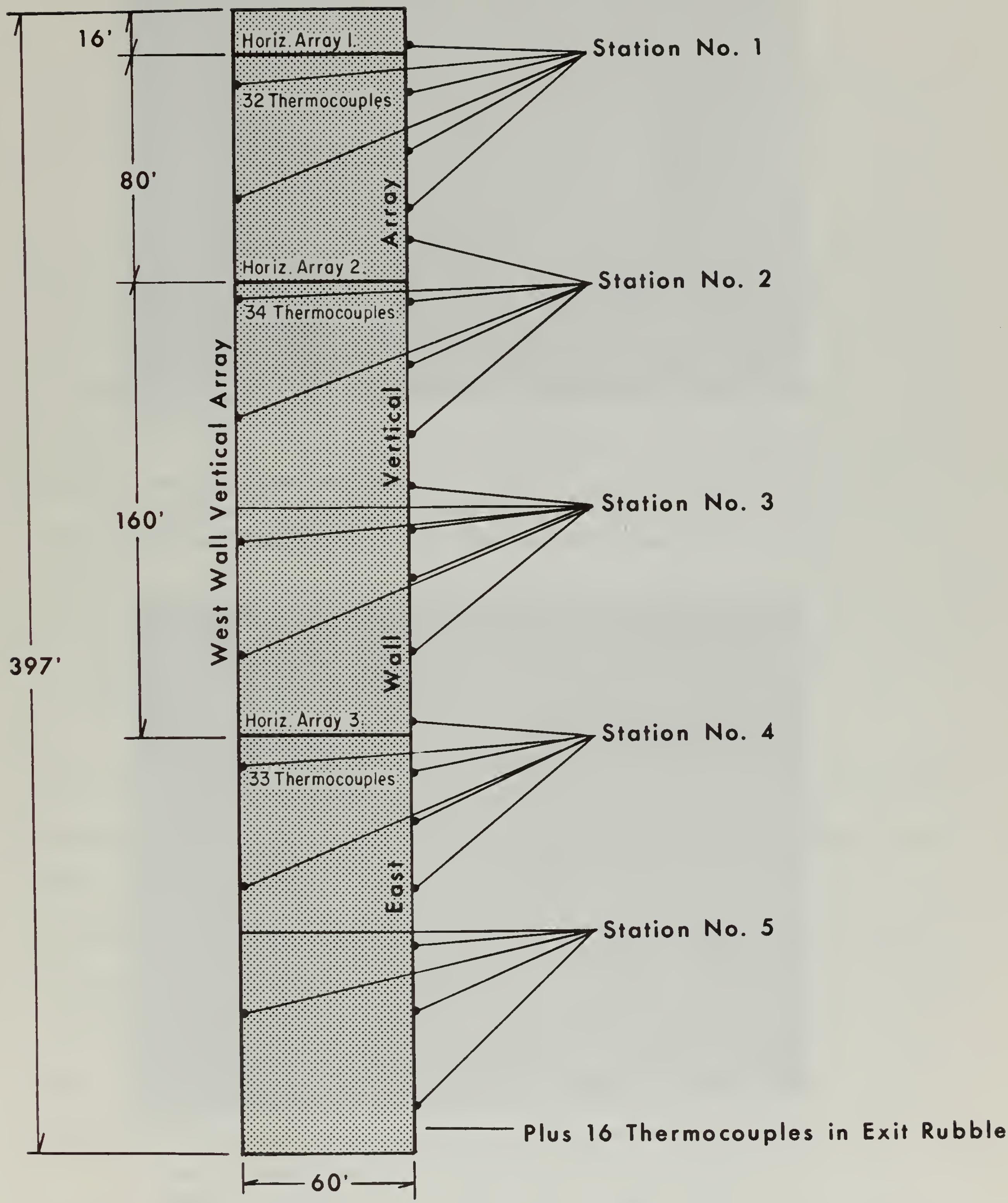


Figure 3-1-8. Thermocouple Locations

Figure 3-1-9. Instrumentation Station
Note drill casings in floor and thermocouple leads to cable tray in right foreground. Shot Crete and Miracoat sealant were applied to help limit leakage.

Figure 3-1-10. Quench and Sampling Systems
At Bulkhead No. 12, the oil sampling probe is run into the oil pool at the base of the retort through the valve and packer arrangement in left center. The retractable quench nozzles go in through valves on upper right.

1.4 OTHER MINE DESIGN CHANGES RELATED TO PROCESSING

The photo on the opposite pages shows the accessible portion of the redesigned Quench and Sampling Systems.

A. Quench System One of the major problem areas during the Retort Zero burn was the inadequate underground quench system for cooling retort off-gas. The original design had only one set of quench nozzles located in such a way that no replacement or cleanout was possible. The system was "pulsed" with high pressure water at frequent intervals throughout the burn. This procedure not only failed to keep the nozzles open but added a substantial amount of sour water to the process. By the time the quench was really needed, the nozzles were plugged and there was no way to cool the gas stream as the burn approached the retort bottom.

The Retort One quench system was redesigned to provide two retractable quench bars which allowed clean out of the nozzles. The quench bars were positioned across the north and south exits of the retort. A secondary quench system was positioned just down stream of Bulkhead 9. A third quench system was installed in a preexisting 8-inch pipe from surface to the product drift. This final "back-up" system could have been used in case of massive caving in the product drift -- a situation which had been discovered at the base of Retort Zero.

Plugging of the quench nozzles due to scale deposits was eliminated by using treated boiler feed water as the quench water supply.

B. Retort Oil Sampling System The oil sampling system for Retort Zero plugged very early in the run. This problem was solved for Retort One by designing a retractable probe sample device that could be inserted through bulkheads 8 and 12. The system performed satisfactorily.

1.5 PHASE III POND CONSTRUCTION

Water management was a major concern prior to the ignition of Retort One. Based on the Retort Zero experience, the Phase I and Phase II sour water and scrubber blowdown ponds were estimated to be inadequate for Retort One. Consequently, an additional 8 million gallon capacity pond system (Phase III) was constructed; this brought the total sour water/scrubber blowdown capacity to about 22 million gallons with 11 acres of evaporative area.

The total surface area of all the ponds was estimated to handle the evaporation of up to 17 gpm groundwater inflow into Retorts Zero and One. This ground water inflow into the burned out retorts is expected to remain sour for many months following the burn. The total evaporation capacity of all the ponds will readily handle the current ground water influx of 7 gpm into Retorts Zero and One.

Figure 3-1-11. Phase III Pond Liner Installation

Figure 3-1-12. Phase III Ponds Complete

2.1 BACKGROUND AND STATUS

Retort Zero was on cool down throughout the year 1981. The retort was burned from October 13, 1980 through December 30, 1980.

A total of 1876 barrels of recoverable oil was produced. Of this total, 1040 barrels of liquid oil were recovered to the tank and 836 barrels of condensible oil were potentially recoverable from the gas stream.

This production gave a recovery of 68% of the oil resource above the brow in the retort. (See Figure 3-2-1 for details)

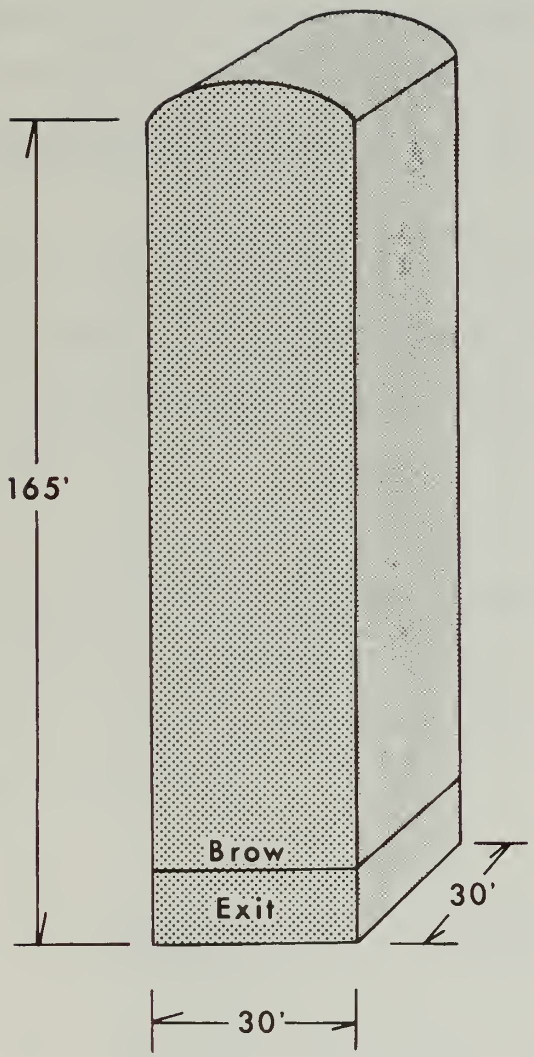
Retort Zero was given a brief steam purge and then shut in. From December 30, 1980 through April 23, 1981 varying amounts of sour water were recycled through the retort.

On May 2 an attempt was made to core drill into rubble near the retort bottom to assess how closely the retorting front had approached the bottom. The retort was under a slight vacuum to protect miners operating the drill. As the drill penetrated the retort wall, products of combustion and retorting began to appear in the off gas, indicating that the rubble there was still hot enough to ignite. The effort was discontinued immediately.

On June 3, 1981 the Retort Zero system was connected to the Retort One system as described on page 2-4-10. A brief inspection showed that the crosscut at the exit from the retort was caved.

During the burn of Retort One, Retort Zero remained connected to the system with a slight flow of inert gas to prevent accumulation of flammable gasses.

At year-end Retort Zero was shut-in for extended cool down.



Resource In-Place

8650 tons shale

17.3 gal/ton

3600 bbls Total In-Place

2761 bbls Available FA Oil
Above the Brow

Production

1876 bbls

52.1% of Oil In-Place

67.9% of Available Oil In-Place
Above the Brow

Figure 3-2-1. Retort '0' Resource and Production

2.2 SOUR WATER RECYCLE STUDIES

From early January through late April, 1981, sour retort water was circulated through Retort Zero for the primary purpose of accelerating the cooling of the hot spent shale following retorting. A secondary objective was to study the leaching effects of sour water recycle on spent shale. During the recycling, numerous water samples were collected and submitted to commercial labs for analysis.

Three separate batches of sour water were processed through Retort Zero. Total water circulation was about 150,000 barrels. During circulation approximately 5,300 barrels of water were consumed by wetting the retort shale.

The rate of recirculation ran from 20 gpm to 40 gpm and occasionally up to 100 gpm. The point of water injection was moved from side to side across the drill holes on the retort top. The salient conclusions and observations were:

- Significant acceleration of cooling was probably achieved. Temperatures in the product drift were low enough to permit inspection in June.
- Rapid channeling of the recycle water was probable. Residence times for passing through the retort were probably only a few hours and not more than two days.
- Probable channeling was also born out by the fact that some of the retort rubble showed tendencies to reignite when small amounts of air were introduced in late May.
- The overall trend for conductivity and TDS in the water exiting the retort showed a gradual increase, indicating some instability of retorted shale minerals with respect to chemical composition of recycle sour water.

Sour Water Recycle Studies (Cont.)

- Dissolved organic carbon (DOC) decreased indicating that organic carbon was being removed from recycled sour water, presumably by absorption into the spent shale.

- Ammonia concentration tended to decrease as it is flushed from the retort.

- Thiosulfate concentration showed an increase over the duration of the sour water recycle which is postulated to correspond to a gradual increase in oxidation potential of the water.

- Arsenic concentration increased rapidly toward the end of the recycle quenching period. This is a further indication that the oxidation potential of the sour water recycle increases with time.

3.1 SUMMARY OF PREBURN TESTING

Prior to ignition of Retort One, a series of pressure and tracer tests were performed. These tests were performed initially on Retort One alone, then on the combined retort system. From these results, retort modifications and operation strategies were formalized.

A. Cold Flow Pressure Drop Pressure drops through the Retort One rubble were measured at various air flow rates. The measured pressure drops indicated substantially less resistance to flow than found in Retort Zero. This indicated that the desired reduction in proportion of very fine material in the rubble had been achieved by reducing the powder factor.

B. Pressure Rise Tests Several pressure rise tests were run to assess the magnitude of retort leakage. These tests also gave some indication of the void volume.

C. Tracer flow tests These tests were conducted in more detail than was possible for Retort Zero. Six separately identifiable freon gases were injected and sampled at three different vertical levels. The test results showed the sweep efficiency of Retort One to be essentially the same as for Retort Zero.

PreBurn Test (Cont.)

D. Mine Leak Testing The Retort One leakage rate (not including Retort Zero leak) was determined by measuring the air required to balance the leakage at a constant pressure (about. 60" H_2O). Leak locations and their relative severity were obtained by adding a known amount of sulfur hexafluoride gas (SF_6) to the input air and taking air samples at strategic points in the mine and analyzing them for SF_6. Figure 3-4-1 shows the sampling points on G level. The major leakage areas were the instrument shaft and the escape shaft. The escape shaft was lined and sealed for 320 feet above sub E level with steel liner plate with grout placed behind it. This resulted in a 90% reduction of leakage into that shaft. The instrument shaft leakage was the most severe. Sealing the instrument station faces with shotcrete and Miracote (polymer sealant) did little to stop the leak into the shaft. Sealing the instrument stations with bulkheads reduced the leakage into the shaft by 50%. This action, plus the lining of the escape shaft, resulted in a 40% overall reduction in the Retort One leak rate; but that was still considered excessive. The final action was to plug the instrument shaft at the top and bottom and provide inert gas injection into the shaft. By maintaining the instrument shaft at the same pressure as the retort, the leakage rate for Retort One was reduced to 22% of its initial value. After all repairs were completed, Retort One was opened to the product collection system; the final total leak rate was only 30% higher than experienced during Retort Zero. This was considered an acceptable leak rate in connection with the plan to operate Retort One under vacuum.

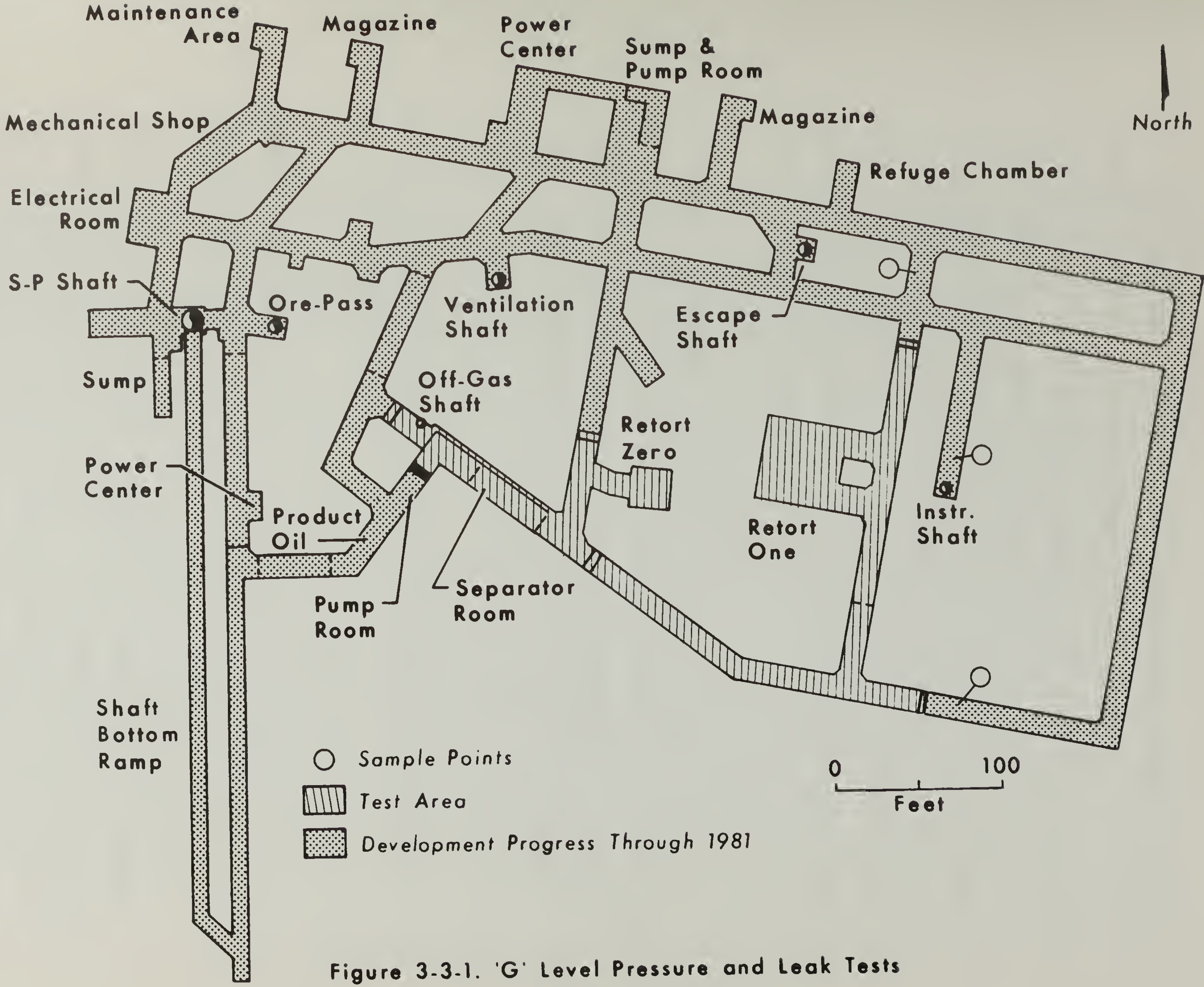


Figure 3-3-1. 'G' Level Pressure and Leak Tests

3.2 RETORT ONE OPERATIONS

A. Ignition Phase The ignition of Retort One was a very successful scale up of RBOSC's ignition system. Following several aborted starts due to automatic shutdown of the burners on receipt of false flame-failure signals, ignition began at 4:15 p.m. on June 21, 1981, and proceeded very quickly, being complete after only 28 hours. It is possible that ignition may have been complete in as little as 12 hours. The oxygen concentration in the off-gas fell below 2% within 2 hours of lighting the burners, far sooner than the combustibles began to rise to potentially explosive levels.

B. Operations Summary Operations of the retort itself proceeded extremely smoothly and very much according to plan. Initial retorting conditions were established using air and steam mixtures. Subsequent periods were run at high flow rates with air only, steam only and varying mixtures.

Pressure drop across the retort behaved very much as predicted by cold flow testing.

Numerous interruptions to planned operating rates occurred due to problems in the gas treatment section of the plant.

Because of the extensive instrumentation of Retort One, much more was known about the shape and position of the flame front than was possible during Retort Zero. The flame front was uneven most of the time and a couple of hot "fingers" were evident. By redistributing the air feed

Retort One Operations (Cont.)

points and using other techniques, it is felt that some control was achieved to prevent premature breakthrough of the flame front.

The main events of Retort One are chronologically listed in Table 3-3-1.

C. Cool Down On December 14, the air feed to Retort One was stopped for the final time and the cool down phase was initiated. Cool down proceeded more quickly than anticipated. The retort was purged with steam and inert gas for six days. Steaming was terminated on December 20 and by December 21, the retort could be vented directly to the flare. On December 23, the retort was blocked in at the top and bottom, with no tendency to pressurize. The estimated 25 SCFM of off-gas produced evidently vented through leaks into the mine exhaust, with no adverse affects on the mine environment.

D. Problem Areas The Retort One burn was relatively problem-free with the exception of the off-gas handling system where several difficulties developed:

- Cross over duct expansion joint
  Early in the run, the Foster Wheeler specified expansion joints between the off-gas incinerator and the scrubber caught on fire and were destroyed. The off-gas was diverted to the flare and the burn rate was greatly reduced in order to minimize SO_2 emissions. An improvised expansion joint incorporating additional insulation was designed and installed. These joints were satisfactory throughout the rest of the run.

- Stack corrosion
  Severe corrosion of the scrubber stack was by far the most serious problem encountered during Retort One. Failure of the protective tar-like Stackfas Mastic

TABLE 3-3-1

MAIN EVENTS OF THE RETORT ONE BURN

Date	Event
6-21	Retort Ignition
6-22	Ignition Completed.
6-24	First oil detected in off-gas.
6-28 - 7-2	Retort shutdown to minimize SO_2 emissions during incinerator/ scrubber expansion joint repair.
7-9	First oil in separator room.
7-26	Stack corrosion problem first noticed
8-9 - 8-19	Retort shutdown to minimize SO_2 emissions during Scrubber Stack repair.
9-2	Another corrosion hole found in scrubber stack.
9-8	Retort shutdown again for extensive stack repairs.
9-19	Air back in Retort under special permission from EPA to emit up to 1000 # per hour, SO_2 from the flare.
9-30	Retort Exit Quench placed in service.
10-20	Stack repairs completed.
12-14	Air removed from Retort for the final time. Shutdown dictated by thermal breakthrough.
12-20	Steaming Terminated.
12-23	Cool-down proceeded very quickly. Retort blocked in from top and bottom.

coating in several areas allowed acidic condensate (pH of 2) to attack the carbon steel stack.

About one month into the run, pin holes were first noticed in the stack. Two weeks later, after an external stack inspection, the off-gas was diverted to the flare to allow an internal inspection of the stack. Again the burn rate was greatly reduced to minimize SO_2 emissions. The internal inspection revealed the corrosion problem to be more extensive than expected. The structural integrity of the stack was in jeopardy. About 50% of the bottom field weld had to be re-welded and 28" x 3/8" rolled steel plate was welded around the entire circumference of the top field weld. The repaired areas were coated with Mastic which was cured on an accelerated schedule in three days.

Two weeks later, another hole had corroded through the stack indicating continued failure of the Mastic coating. Again the burn rate was reduced and the off-gas was diverted to the flare. All of the mastic patching from the last repairs had failed. It was decided the entire stack interior had to be re-coated with Mastic. All the old Mastic was removed by hydro-blasting; the few new holes were patched and a new coating of Stackfras Mastic was sprayed on. This time the Mastic was properly cured over a 15-day period. The entire repair period lasted 43 days. Fortunately, 10 days into the repair period, permission was obtained from the EPA to emit 1000 lb/hr SO_2 from the flare so that a substantial burn rate could be maintained during the rest of the repair period. Internal inspection of the scrubber stack shortly after the end of Retort One showed that the new Mastic coating held up extremely well through the rest of the burn.

- Incinerator refractory
  After Retort Zero, it was discovered that a large part of the incinerator refractory had fallen off during the run. A contractor was hired to make repairs. Some weeks into the Retort One burn, the refractory had begun to fall off again. Rather than shut down and make repairs, water was sprayed on the outside of the incinerator to keep the affected area cooled. This worked well enough to get through the rest of the burn.

E. Post Burn Studies Detailed analysis of Retort One data is in progress and will continue for a number of months. However, it can be concluded that the burn of Retort One was a technical success in the following respects:

- The oil recovery for Retort One stands at 24,444 barrels of which 5,880 barrels represents the potentially recoverable oil in the off-gas. The total amounts to 68% of the available Fischer Assay oil above the brow. The brow is the roof of the retort exit below which essentially no shale can be retorted. (See Figure 3-3-2)

- The rubbling technique again produced a satisfactory distribution of void space resulting in good gas flow distribution with relatively low pressure drop.

- Retort One was rubblized safely while Retort Zero was being burned.

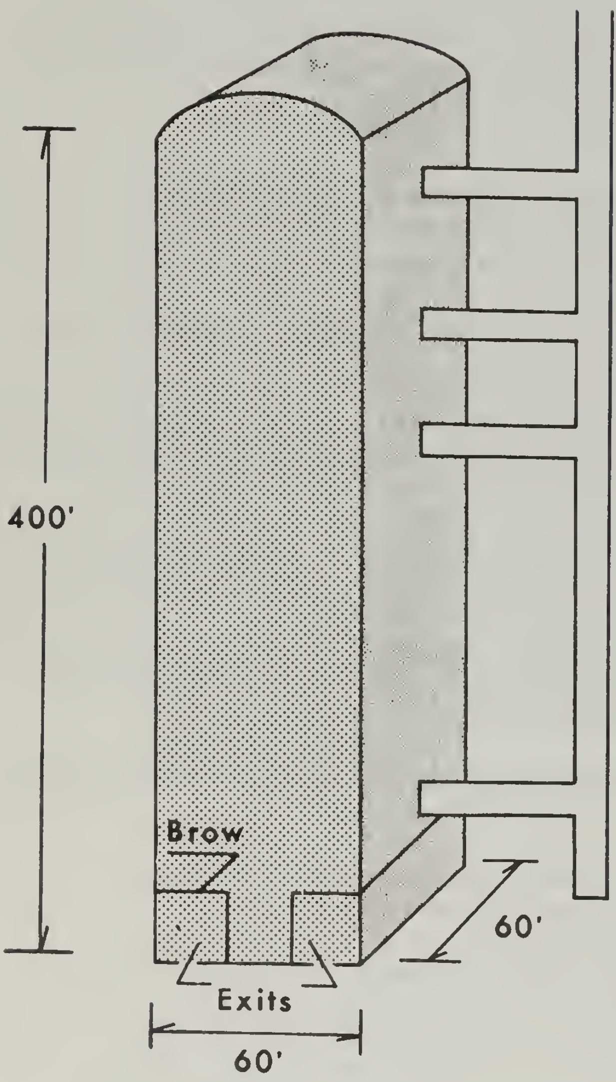
- The ignition of Retort One was very fast, being complete after only 28 hours Oxygen concentration dropped below 2% in less than two hours.

- The burning of Retort One under continuous vacuum operation (up to 60" w.c.) was achieved.

- Even with the restrictions of vacuum operation, a burn rate of almost 3 feet per day was achieved, excluding periods of curtailment for repair of the gas treatment plant.

- The process control equipment and instrumentation performed as expected.

- The gas treatment plant (incinerator, scrubber, stack) satisfactorily controled the sulfur emissions when operating. However, mechanical difficulties with the crossover duct and stack caused 60 days of outage. The H_2S production rate for Retort One was about one-third of that for Retort Zero. No explanation is yet available for this difference. In spite of the problems in off-gas treatment plant operation there were no detectable excursions in air borne sulfur compounds found at the off-tract air quality monitoring stations.



Resource In-Place

71,600 tons

21.6 gal/ton

36,900 bbls Total In-Place

35,930 bbls Available FA Oil
Above the Brow

Production

24,444 bbls

66.2% of Oil In-Place

68% of Available Oil In-Place
Above the Brow

Figure 3-3-2. Retort '1' Resource and Production

Surface Retorting -- Lurgi Demonstration

In March and April of 1981, engineering contractors were completing cost estimates on the proposed 4,400 ton per day Lurgi-Ruhrgas surface retort demonstration project to be built on land just north of Tract C-a. These estimates were far higher than originally anticipated. The project was placed on hold and then deferred indefinitely pending study of other scale-up demonstration alternatives and/or possible cost reductions.

SECTION IV

ORE STORAGE

4.1 ORE STORAGE

No significant additions were made to the run of mine (ROM) ore storage pile during 1981. The approximate quantity is 119,000 loose cubic yards or 171,000 tons. 1/

Approximately 87 tons of oil shale with a high dawsonite content was mined and placed in drums for shipment to research laboratories.

The localized heating problem discovered in late 1980 was evaluated and resolved. The probable cause of the heating was a combination of oxidation reactions involving iron sulfides, moisture and limited heat conduction at certain depths in the pile. The area of heating did not relate to any particular characteristic of ROM shale except perhaps a concentration of certain pyrite species. The hot spot was dozed out from a depth of 15 to 20 feet. Thermocouples placed around the remaining pile have shown a steady decrease toward ambient temperature.

In 1979 a lysimeter was established in a portion of the ROM shale pile to collect samples of water percolating down through the raw shale. During 1981 the lysimeter functioned from March 20 through October 30. Freezing during the winter months required some curtailment of the program. Interim results of this work (done in conjuction with Colorado State University and the USGS) are described briefly in Section VII Chapter 6.5 of this report.

1/ This quantity exceeds earlier estimates because of more exact estimates of quantities excavated underground. See Table 2-4-2 for year-by-year tabulation.

SECTION V

SUPPORT FACILITIES

Support for the mining and process activities at Tract C-a was provided primarily by the Service Operations Group. The major working units of this group are the mechanical shop, heavy equipment shop, light construction shop, water operations, communications, material handling, and transportation. The chapters that follow highlight some of the activities of this group.

During 1981 RBOSC continued the policy of providing mass transportation to Tract C-a from the population centers of Rifle, Meeker and Rangely. The bus/vanpool operation went from 325 users in January to under 110 users in December. Vehicles employed dropped from 4 buses and 6 vans to 2 buses and 5 vans running at year end.

Other elements of the transportation system include the airstrip on 84 Mesa and the new access road to the Lurgi Demonstration Site.

1.1 AIR STRIP

The 84 Mesa Airstrip operated essentially without problems during the year except for a short period in June when repairs were completed on the parking apron. Several soft spots had developed which required corrective measures. Better base material was placed in the soft areas and an additional 2½ inches of asphalt was applied on the parking apron. To reduce the possibility of moisture penetration on the main airstrip, a seal coat was applied and the strip repainted. Agreements were signed with four other energy companies for use of the air strip.

In January a heli-pad was completed adjacent to the mine rescue building, specifically located for the St. Mary's Hospial Air Ambulance.

1.2 LURGI ACCESS ROAD

The basic excavation and subgrade for the road began in late 1980 to reach the Lurgi Demonstration Plant Site and was completed in February 1981. Base course gravel placement, guard rails and paving were postponed. The road is open for maintenance purposes only.

2.1 ELECTRICAL

No significant changes were made to the electric power distribution system during the year.

Electrical power consumption increased in 1981 versus 1980, mainly due to extended retort burning in 1981.

Power interruptions amounted to one unplanned outage and four planned outages. All power outages were short term and were readily covered by the 1000 KW emergency generator and the 2500 KW standby generator.

2.2 NATURAL GAS

No significant changes were made to the gas distribution pipelines during the year.

The average gas consumption for 1981 was approximately 30,000 MM BTU/month versus just over 19,000 MM BTU in 1980. The increase was due to process operations consumption. Higher operating rates, with increased steam generation and incineration requirements contributed to this consumption.

The off-gas incinerator, steam boiler and mine intake air heaters were the principal consumption points.

Overall, the water management system operated through the year with considerably fewer problems than experienced during 1980. The estimated volumes of process water did not materialize and the Phase III pond construction provided adequate evaporative capacity to handle long-term sour water requirements.

3.1 POTABLE WATER

The potable water plant was operated and monitored on a daily basis according to the Colorado State Primary Drinking Standards. Since April 1980 the plant has produced more than 2 million gallons, for an average of 5,500 gallons per day (gpd) of potable water. At year end, usage was down to 4,000 gpd versus 7,000 gpd consumed in January 1981. During the year, Spring #8 in Box Elder Gulch was developed as a backup source for potable water. The spring water requires less treatment prior to being pumped into the potable water system than mine water. The spring runs up to 100 gpm during the spring and summer. For the first time since records were kept, the spring flow fell off to 2 gpm in December. This reduction in flow was possibly caused by freezing as the new spring collection system is close to the surface of the ground and uninsulated. Substantial water flow resumed in the spring of 1982.

3.2 SEWAGE TREATMENT

The sewage treatment plant is presently operating at less than 5,000 gpd, which is 40% of its capacity. In May, 1981, RBOSC started a CDOH approved program of discharging treated sewage effluent directly to

Corral Gulch. There have been no plant upsets or major difficulties during this operation. The change was made to reduce inflows to the East Pond.

Valley Disposal Company of Meeker disposed of approximately 6,000 gallons of aerated digested sludge during 1981. An air line to the sewage treatment plant was installed from the mine air compressors to cut the costs associated with the sewage plant blower operations.

3.3 DEWATERING AND REINJECTION

The total dewatering rate ranged from 1600 gpm down to 1200 gpm through the year as wells D-6 and D-8 were shut off. The mine pump rate increased very little. The booster pump station in Box Elder Gulch was shut down on June 5, 1981 due to ground subsidence problems affecting the pump foundation. Subsequent operations established that the main reinjection pump could develop enough pressure to deliver water to all the reinjection wells.

Total water handled was down somewhat in 1981 with approximately 2620 acre feet of water pumped as mine seepage and dewatering well water during 1981, as compared to the approximately 2860 acre feet pumped in 1980. Of this total dewatering production, approximately 82% was reinjected or some 2145 acre feet (down slightly from the 2200 acre feet of water reinjected in 1980). The remaining 18% was consumed in the plant and used for dust suppression. Total dewatering production from 1978 through 1981 was 11,426 acre feet. Total reinjection through 1981

was a little under 6207 acre feet. Table 5-3-1 summarizes Tract water handling.

Table 5-3-1

Tract C-a Water Handling - 1981

	Total Production (MMGal)	Total Reinjection (MMGal)
January	83.0	70.5
February	74.2	62.5
March	78.6	67.4
April	73.4	66.1
May	73.2	65.8
June	72.1	64.8
July	72.5	63.8
August	72.9	51.1
September	69.1	48.4
October	69.6	50.2
November	64.2	48.2
December	50.7	40.2
Total 1981 - MM Gal.	853.5	699.0
Total 1981 - Acre Ft.	2619	(2145)

Table 5-3-2

Tract C-a Water Handling

Life of Project

Year	Reinjected	Total Groundwater	% Total Grounwater Reinjected
	AF	AF	
1978	1080	3080	35.1
1979	791	2870	27.6
1980	2191	2857	76.7
1981	2145	2619	81.9
Total	6207	11426	54.3

3.4 PONDS

A. East Pond In 1981, the East Pond was classified as a "No Discharge Process Collection Drainage Pond", consistent with the original design concepts. During Retort Zero operations, the East Pond had filled quite rapidly and it became important to draw dust suppression water from it. A direct discharge was also authorized to relieve the pond based on sample data available at the time. As the discharge got underway (March 23) sample data came back indicating possible stratification, with more highly contaminated water deep in the pond. All withdrawals from the pond were stopped (March 26). During the Retort One burn, water for quenching the incinerator discharge gas was drawn from the East Pond. This consumptive use together with other recycle measures effectively solved the East Pond problems.

B. Evaporation Ponds With the completion of the Phase III ponds in September, a total of 11 acres of evaporative capacity was established, capable of handling up to 17 gpm of sour water for an indefinite period. All 12 ponds are lined and equipped with leakage detection systems. The storage capacity of these ponds did not become necessary because of the low scrubber blow-down production during Retort One burn: the sulfur content of the gas was one-third that of Retort Zero and the scrubber was out of commission for nearly sixty days due to mechanical problems with the ducting and stack.

In November a leak was discovered around Pond 5. The problem developed when the buried pumpline used to pump scrubber blowdown liquid up to the

ponds became plugged. The operators switched to a return line. A vacuum relief valve had been left open (routine situation) and an estimated 15,000 gallon of scrubber water leaked into the surrounding soil before the condition was discovered. This was determined not to be hazardous or reportable under RCRA or Superfund regulations.

In an effort to assess the effectiveness of evaporation enhancement by spraying, an evaporation test was started during October 1981 utilizing Sour Water Ponds 3 and 4. The test was discontinued during November because of freezing weather. This test was restarted in May, 1982.

C. Jeffrey Pond The small Jeffrey Pond has been effectively operated as a rapid settling basin for the mine dewatering water and a portion of the site runoff sewer drainage. Flocculant is added to the mine water before entering the pond. The Jeffrey basin was cleaned of sediment twice during the year. This system has largely solved the suspended solids problem in the west pond.

D. West Pond West Retention Pond water is drawn for process water, dust suppression water and as supply to the potable water plant. The balance is reinjected. This system ran without incident during the year.

E. Skimming Equipment The floating oil skimming equipment proved ineffective on the East and West Ponds and both units were removed. A fixed floating "boom" and skimming from the bank were found to be more effective.

Communications systems remained essentially unchanged during 1981. The principal elements of the system were composed of the following:

- Local telephone system through the Meeker exchange (878-4053) with up to 18 lines available.
- WATS lines for out-of-state calls.
- SOCON (Standard Oil network) for calls to the Denver area.
- Mobile 1-channel radio system for heavy equipment and vehicles in vicinity of Tract.
- Hand held radios for process control and special needs.
- Mine-pager telephones for communications underground.

Storage & Distribution of Fuel & Other Service Products

Material handling in 1981 kept pace with that of 1980. The total number of receiving reports and shipping orders in 1981 was 5923 versus 6374 in 1980. This steady pace of approximately 24 handlings per working day was mainly due to the work involved in preparing the process area for the burn of Retort One.

The computerized gas dispensing installed in 1980 proved to be an effective way of monitoring the use of gasoline. This system uses a coded card to obtain access to the fuel system with each piece of equipment having its own card. Unaccounted losses were reduced from approximately 50 gallons per week to essentially none after this program was initiated. The information from this system was also used in the vehicle maintenance program to calculate fuel consumption. The reduction in gas and diesel usage in 1981 allowed RBOSC to discontinue the use of four reserve fuel tanks stationed in the parking lot area. The total usage of fuel is presented in Table 5-5-1.

The first quarter of the year started with the construction of a warehouse receiving area and related security improvements, (yard lighting and additional fencing).

Table 5-5-1

Fuel Usage - 1981

Quarter	Gasoline (Gallons)		Diesel (Gallons)	
	1980	1981	1980	1981
1st.	42,970	35,863	35,000	18,200
2nd.	40,766	27,779	68,980	8,900
3rd.	51,017	20,755	50,810	7,190
4th.	43,206	14,389	48,031	6,480
	117,959	98,786	202,821	40,770

No major building construction took place during 1981. Several remodeling jobs were completed to consolidate operations and improve efficiency.

The warehouse in the back of the Administration Building was consolidated into the main warehouse with the vacated area converted into additional office space.

The Mine Dryhouse was modified to isolate work clothes from street clothes in connection with the Personal Hygiene Program in effect during Retort One. These changes included the installation of a washer-dryer setup with storage for control and daily issuing of laundered clothing.

SECTION VI

ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

This section contains discussions on the following areas: Health and Safety; Fire Prevention and Control; Air Quality Control; Hazardous Waste Control; Land Rehabilitation and Erosion Control; Solid Waste Control; Fish and Wildlife Management Plan; Protection of Objects of Historic and Scientific Interest; and Subsidence Control. Water quality control was discussed in Section 5, Chapter 3, and will not be repeated in this section. Detailed information of the experimental revegetation section is included in the MDP Monitoring Report 8 submitted to the OSO under separate cover.

2.1 GENERAL HEALTH AND SAFETY PRACTICES

The Tract safety and health program was further refined during 1981, emphasizing training, emergency preparedness, and safety incentives. The safety record of the Tract operations was much improved.

A. Training During the year MSHA compliance training, which included annual refresher courses, was conducted by seven on-site personnel with appropriate MSHA certification to instruct.

The approved courses included the following: Mine Rescue, Mine Emergency, Accident Prevention, Hazard Awareness, Respiratory Devices, Flame Safety Lamp, Mine Gas Detection, Oxygen Analyzer, Health, Explosive Hazards, Electrical Hazards, Ground Control, Communication, Transportation, First Aid, and Cardio Pulmonary Resuscitation. Supervisory training during 1981 stressed job safety analysis and accident reporting with emphasis on how to analyze an accident or near-miss to prevent future accidents. Special training was also conducted on retort ignition and operating procedures.

B. Emergency Preparedness The provision of two Emergency Medical Technicians (EMT's) on all working shifts was the main element of emergency preparedness. During 1981, a contract was finalized with St. Mary's Hospital to provide "Physician Advisors" and sponsor the two Tract C-a ambulances, as well as provide continuing monthly training to the on-site EMTs. This arrangement replaced earlier arrangements with the Palisade Clinic.

In addition to the on-site EMT's, RBOSC contributed substantially to maintain the St. Mary's Hospital Air-life Helicopter which can provide advanced medical treatment within 40 minutes.

C. Incentive Program A safety incentive program (covering all personnel working on Tract) was initiated during 1981. Safe workers can earn increasingly valuable awards by extending their accident-free record. Group awards help stimulate interest in working together to prevent accidents. In addition, policy was clarified that safety record would be part of each individual's performance review.

D. Safety Record During 1981 The cumulative result of all these efforts was a much improved safety record for 1981 as shown by Figure 6-2-1 which summarizes accident statistics for the year. The frequency of 1.74 accidents per 200,000 manhours compares to 5.7 for 1980.

Through February 26, four lost time accidents occured:

1-26-81	Process Operator Moving oxygen cylinders Strained back	Back Injury (aggravated an old injury) Required surgery
2-2-81	Surface Driller Working with power tongs caught hand	Smashed Finger Required Surgery
2-4-81	Miner Pulling long-hole drill casing with pipe wrench	Back Strain 4 days off
2-25-81	Surface Laborer Cleaning Dry Room wooden floor rock fell down catching leg	Contusion to Leg Required drainage

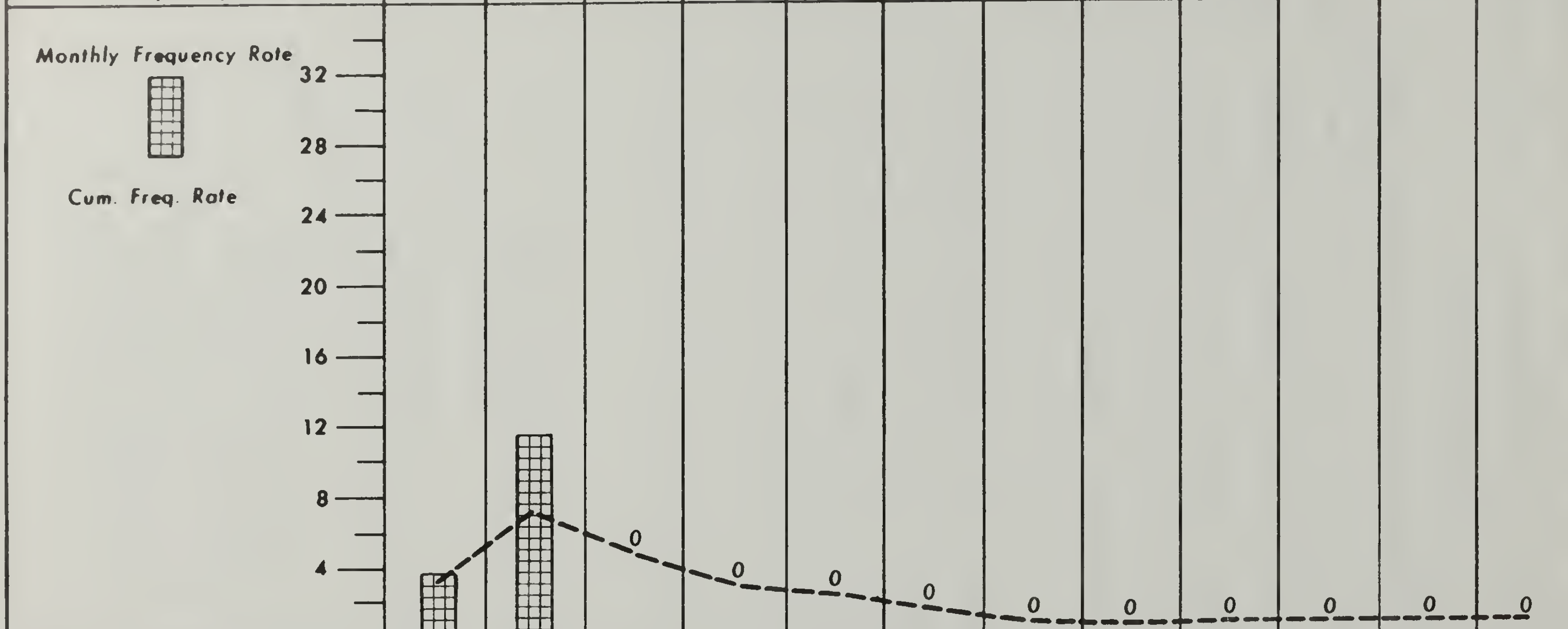
During the balance of the year Tract C-a worked:

10 MONTHS

360,000 Man Hours

without a lost-time accident.

Rio Blanco Oil Shale Company
ACCIDENT STATISTICS FOR TRACT C-a/1981



Frequency Rate	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan/Dec
Man-Hours Exposure per Month	55746	51456	52904	45915	42568	40576	45042	32835	26432	25168	20288	21860	
Total Man-Hours Year to Date	55746	107202	160106	206021	248589	289165	334207	367042	393474	418642	438912	460852	
Number of Lost Time Accidents	1	3	0	0	0	0	0	0	0	0	0	0	
Number of Lost Time Days	9*	46**	70**	114	135	157	180	201	224	244	266	266	
Monthly Frequency Rate	3.6	11.7	0	0	0	0	0	0	0	0	0	0	
Cumulative Frequency Rate	3.6	7.5	5.0	3.9	3.2	2.8	2.4	2.2	2.0	1.9	1.8	1.74	

Remarks: *TIC (Kettle) carry over 5 days from 1980
**Colo. Well Service (Shelton) = 64 days
Note. (MSHA Accident Frequency Rate) = (Number of Lost Time Injuries) (200,000)/Number of Manhours Exposure

Figure 6-2-1. Accident Statistics for Tract C-a During 1981

2.2 INDUSTRIAL HYGIENE

A scientific team from Los Alamos Laboratories conducted a survey on mine gases and dust. Periodic dust and noise sampling was done by Tract C-a safety personnel. No excessive exposures were detected in these surveys.

The personal hygiene program in effect during Retort Zero consisted of providing shower facilities for daily bathing plus issuing coveralls and/or wet gear to protect workers coming in direct contact with oil.

Based on Gulf Oil Corp. recommendations, a more intensive program was adopted for Retort One. The program consisted of:

- Complete change of all clothing every day with laundering done on site.
- Mandatory shower after every shift for all workers in process areas.
- Immediate cleanup and shower in case of known direct contact with oil.
- Change of shoes to prevent tracking of shale oil home.
- Expansion of coverage to include all employees in the process area and underground product pump areas.

This program was patterned after Gulf's practice and findings in their Solvent Refined Coal (SRC) operations.

3.1 FIRE BRIGADE

During the year a total of 30 employees received partial training to back up the 18 fire brigade positions. During the third quarter the fire brigade was reduced to two six-worker crews. This was prompted by a partial reduction of forces.

Fire brigade members maintained familiarity with the operation of the pumper truck, water hydraulics, and foam applications. Each member has received "hands on" training in the use of dry chemical fire extinguishers. The fire captain conducted monthly fire prevention inspections and two fire brigade members inspect all fire extinguishers and rebuild spent ones.

All employees received "hands-on" training in using small extinguishers to fight an oil-fed pan fire.

3.2 MINE RESCUE

Ten new men were trained in Mine Rescue during the year. These men were trained to replace others who had been lost as mining operations were curtailed. At years end there were 22 active members. The members receive four hours of training per month, which includes at least two hours working under oxygen breathing apparatus.

One means of keeping mine rescue teams trained is participation in regional competitions. The Tract C-a Competition Team competed in the

Glenwood Springs Mine Rescue Contest Novice Class on July 31, 1981. They also completed in the Western Regional Mine Rescue Competition on September 25, 1981 in Grand Junction.

All mine rescue members have had "hands on" fire extinguisher training. They have also tested and operated the foam making machines used to fight underground fires. Sixteen members of the mine rescue team have attended training sessions with the surface fire brigade to learn operation of the pumper and fight surface fires.

3.3 EMERGENCY PROCEDURE MANUAL

The Mine Emergency Procedures Manual was originally prepared and issued in August, 1980. This manual is a compilation of procedures, organizational duties, and check lists to be utilized in the event of a mine disaster. The manual has been updated to keep current with the changing organization at the Tract.

The Process Operations Manual was updated for Retort One. This manual included extensive consideration of emergency procedures for the retorts and process facilities.

4.1 SUSPENDED PARTICULATES

Tract C-a continued its dust control measures during 1981, using water sprinkling trucks for applying water as required in the construction and unpaved road areas. A chemical palliative was applied to haul roads and heavy traffic areas. The following lists the amount of water and dust palliatives used:

1981 WATER AND DUST PALLIATIVE APPLICATION, TRACT C-a

Quarter	Water (Gallons)	Additive
1	129,850	None
2	1,235,500	None
3	1,081,000	16,000 lbs. Lignosite
4	132,000	None

Burning of slash from the evaporation pond construction area was done in accordance with the Open Burning Permit from the Colorado Air Pollution Control Division.

4.2 RETORT OFF-GAS, SULFUR COMPOUNDS

Retort Off-gas was treated during most of the Retort One burn by incineration to oxidize sulfur compounds and hydrocarbons before scrubbing and discharge to the 200-foot high stack. As mentioned in the Processing Section, the gas treatment plant was out of commission for

about 60 days during the run. During that time, operating rates were reduced and the gas was burned at the flare.

5.1 HAZARDOUS WASTE

During 1981 RBOSC activities at Tract C-a relating to hazardous waste included continuing compliance with RCRA regulations and disposal of hazardous wastes. Compliance activities included inspection of tract hazardous waste management facilities; testing of wastes to determine their hazardousness under RCRA; required RCRA training of 220 tract personnel (May and June 1981); and preparation of a plan for the control of oil, hazardous materials, and hazardous wastes in response to RCRA regulations requiring preparation of such a plan. The plan is not final, due to changes in RBOSC operations. Hazardous waste disposal activities involved oil from on-site transformers which was contaminated with low levels of polychorinated biphenyls (PCB's). This contaminated oil was transported to a disposal site in Arkansas in November, to be incinerated. The disposal effort was carried out in compliance with all applicable regulations.

In addition to the compliance and disposal activities described above, RBOSC was also involved in an inspection of RBOSC hazardous waste management facilities. The inspection was conducted by EPA in November.

LAND REHABILITATION AND EROSION CONTROL

6.1 GENERAL

Activities related to land rehabilitation and erosion control are performed in compliance with OSO and lease requirements, as well as stipulations contained in RBOSC's Regular Permit (No. 77-497) from the Colorado Mined Land Reclamation (CMLR) Division. Technical revisions to the CMLR permit approved by the CMLR Board are presented in Table 6-6-1. Due to reporting constraints for the CMLR permit, data reported herein cover activities on Tract C-a from February 1, 1981 through January 31, 1982. However, because of limited activity during winter months, these data correspond closely with the January-December reporting period for the Tract C-a Annual Progress Report.

6.2 AREAS DISTURBED DURING 1981

Total new disturbance during this reporting period amounted to 9.5 acres, considerably lower than the 35.0 acres estimated in the 1981 Annual Report. The discrepancy is due to reduced activity in development of the water reinjection system, reservoirs and soil pits. The new disturbance was associated primarily with construction of additional scrubber blowdown ponds (Table 6-6-2, Figure 6-6-1).

In addition to the newly disturbed areas, several sites were redisturbed during the reporting period. Topsoil material stripped prior to the construction of the Phase III scrubber blowdown ponds was added to Soil Storage Pile 4, located east of the ponds. This soil material was stripped as per depths shown on the soil maps submitted with the

aforementioned permit, stripping being modified as necessary by on-site observations. Redisturbance was to the north and east sides of Pile 4.

TABLE 6-6-1
Technical Revisions Requested and/or Approved During the Reporting Period, February 1981 through January 1982

Date Requested	Subject of Revision	Resolution of Request
February 6, 1981	Development of Spring No. 8 in Box Elder Gulch as a possible potable water source.	Approval confirmed in CMLRB letter of March 3, 1981
June 2, 1981	Development of a slurry trench test in Water Fork of Corral Gulch to study MIS-retort abandonment procedure.	Approval confirmed in CMLPB letter of July 10, 1981
November 6, 1981	Development of a simulated disposal pile bench to study water harvesting techniques and planted shrub development.	Approval confirmed in CLMRB letter of November 16, 1981

Table 6-6-2. ESTIMATES OF MDP ACREAGES DISTURBED AND ACREAGES REVEGETATED 1/

Disturbed Area	Disturbance Magnitude	Acreages Disturbed 1977	1978	1979 2/	1980 3/	1981 4/	1982 5/	Acreages Revegetated 1978	1979 6/	1979 7/	1980 8/	1981 9/
Mine Service Area,	Major	48.2	3.2									
Ponds & Plant Site												
Retention Ponds								8.0				
Plant Side Slopes								12.0				0.2
Area Near Hunting Club								2.0	1.0			
Area Between Water Tank & Plant Site								5.0				
Diversion System			4.2					3.0	3.0			
Settling Basins			3.4					1.0	1.0	0.1		
Equipment Yard								3.0				
Area Near Substation									1.0			
Access/Service Roads	Moderate	10.0	3.0	0.4	17.0			6.5	6.5	0.5	0.8	1.5
ROM Disposal Area	Major		12.3					10.0				
Soil Storage (1,2,3,4) Storage A, B, C, D	Moderate	4.0	3.0		1.4	0.5		3.0		1.3	1.4	1.8
Powder Magazine	Moderate	0.9			0.2							
Water Reinjection System	Moderate		12.2	13.8	4.0			7.0			10.3	12.7
Spring #8	Moderate					0.1						
Transmission Line	Moderate		0.5		0.7							0.1
Natural Gas Pipeline	Moderate			0.8								
Reservoirs & Soil Pits	Major											
Access Road Sand Pit			9.5						5.0		4.5	
Hunting Road Clay Pit			4.0	0.9				2.0				
Monitoring Facilities	Moderate		0.2		3.5		10.0				2.6	3.0
Simulated Disposal Bench	Moderate					1.0						
Trailer Parking Facility					0.5						0.2	
Run-Off Diversion Ditches	Moderate					0.2						0.9
Evaporation Field	Major		7.0									
Scrubber Blowdown Ponds	Major			8.9	8.0	7.2					1.8	2.4
Scrubber Blowdown Pond Pipeline	Moderate			0.05								
Airplane Ridge Road Relocation	Moderate			1.9								
Shale Grouting Trench Test	Moderate					0.5						0.5
Old Airplane Ridge Road Segment									8		0.8	0.8
TOTALS		63.2	62.5	26.8	35.3	9.5	10.0	62.5	26.0	1.9	22.4	23.9

1/ Acreages revised from 1979 Annual Report based on "as built" survey data
2/ Includes acreages disturbed between February 16, 1979 and February 29, 1980
3/ Includes acreages disturbed between February 29, 1980 and January 31, 1981
4/ Includes acreages disturbed between February 1, 1981 and January 31, 1982
5/ Estimated disturbance for reporting period February 1982-January 1983
6/ Areas seeded May 1979
7/ Area redisturbed during 1979 and reseeded in November 1979
8/ Area seeded October and November 1980
9/ Areas seeded October and November 1981

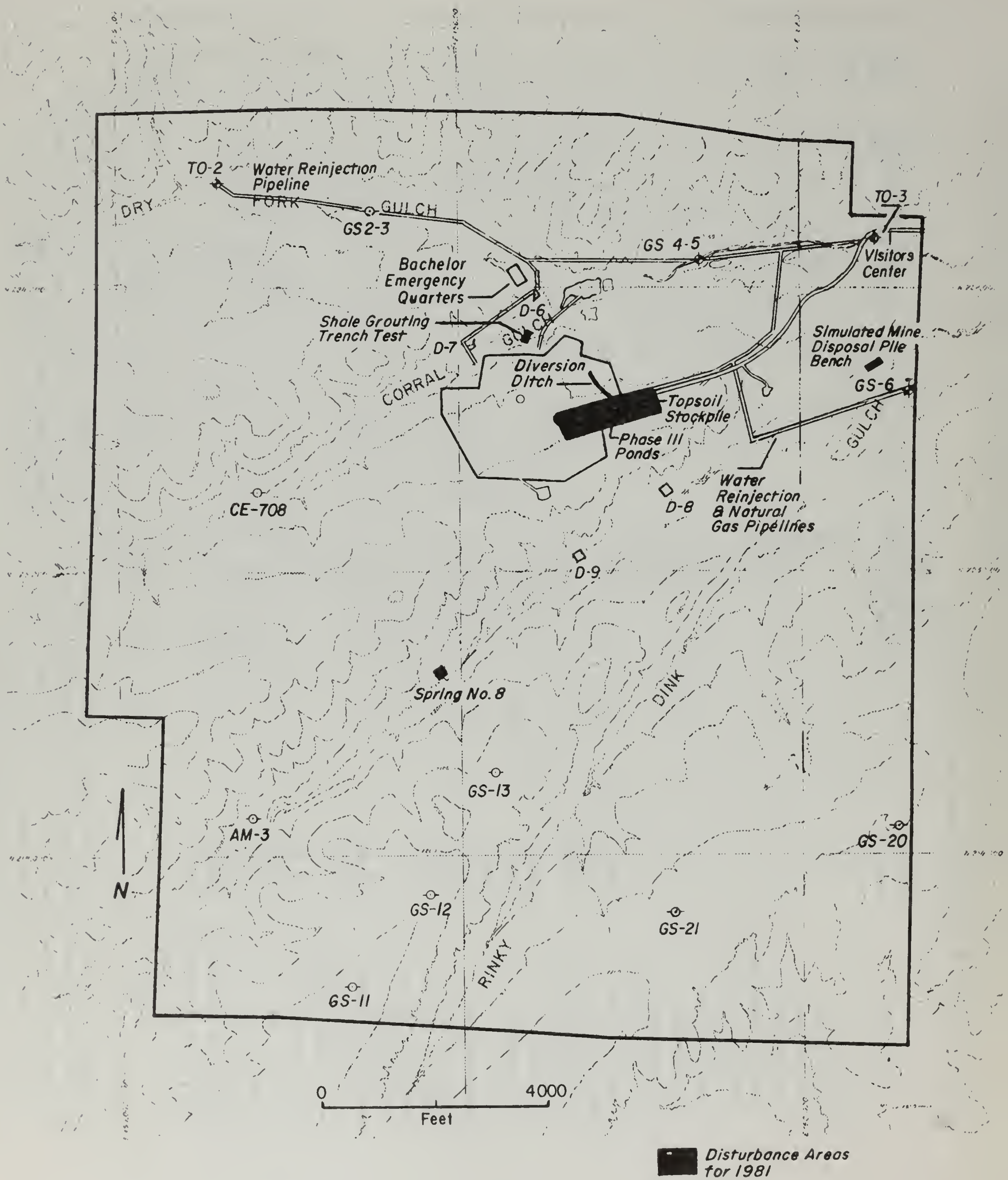


Figure 6-6-1. Tract C-a Disturbance Areas for 1981

Portions of the Access Road Sand Pit and the Hunting Club Road Clay Pit were also redisturbed during the Phase III pond construction. Access to the Sand Pit was via the old Airplane Ridge Road, portions of which were initially seeded during May 1979. Access to the Clay Pit was by the established Corral Gulch Road and the Hunting Club Road. It is not anticipated that either borrow pit will be active in 1982.

An area north and west of the booster pump station in Box Elder Gulch was disturbed due to a break in the reinjection pipeline. These areas were cleaned up and reseeded during this reporting period.

6.3 WATER BARS AND DIVERSION DITCHES

In conjunction with disturbance which occurred during the reporting period, a number of diversion ditches were installed to reduce and/or control erosion. The diversion ditch located to the north of the access road and downslope from the Phase III Scrubber Blowdown Ponds is designed to collect any discharge from the ponds and direct flow into the East Settling Basin. Normal runoff from the outslopes of the ponds is channelled via the existing ditch between the pond slopes and the access road. A diversion ditch to the south of the Phase III ponds catches runoff from the Airplane Ridge Road and surrounding area, and channels this flow around the pond area. A ditch below the topsoil stockpile, located to the east of the Phase III ponds, is designed to retain runoff from the pile.

Construction of a simulated mine/disposal pile bench was initiated during the reporting period. Diversion ditches above and below the bench site are planned; however, construction delays due to winter weather prohibited completion of these diversion ditches. One completed, the ditch upslope from the test site will divert runoff around the study area, while the ditch located below the site will collect any runoff or erosion from the study area.

No new water bars were required for any of the activities undertaken during the reporting period. However, existing water bars on roads and along the dewatering/reinjection system were maintained.

6.4 AREAS SEEDED DURING 1981

A total of 23.9 acres was seeded during the reporting period (Table 6-6-2). All of these areas were seeded during October-November 1981. Of the total, 2.6 acres were hydroseeded while the remaining 21.3 acres were drill seeded using the appropriate seed mixes (Tables 6-6-3, 6-6-4). No fertilizers were applied during the reporting period.

The number of acres seeded during the reporting period relative to the total newly disturbed acreage was controlled by the type of disturbance. A total of 4.8 acres (the Phase III scrubber blowdown ponds) cannot be seeded until final reclamation of the plant site occurs.

6.5 STATUS OF ACREAGE SEEDED DURING 1978

Seeding success was assessed quantitatively during late August 1981 by estimating cover within a 1 m^2 sampling frame. Sampling was conducted at 5 m intervals along permanently established transects within the seeded areas. When seeded areas were redisturbed and/or reseeded during 1981, coverage was not quantitatively assessed during the reporting period. Revegetated areas will be surveyed in subsequent years, with cover estimates being taken along permanent transects at the end of each growing season. Standing crop will be determined during the 5th and 10th years after seeding.

The acreage revegetated in 1978 is listed on Table 6-6-2 and illustrated on the Areas Disturbed By Year Map. A total of 11 transects was established in these areas and, for reporting purposes, seeded areas were grouped into three major categories (soil storage piles, water reinjection system, and mine service area). Table 6-6-5 summarizes the cover values by growth form for these three categories.

TABLE 6-6-3

Seeding and Mulch Regimes Used on Tract C-a 1/

Disturbed Area	Seed Mixture	Seeding Method 2/	Seeding Rate (lbs./A)
Soil Storage Pile B	2	D	16
Soil Storage Pile D	2	D	16
Access/Service Roads	2	D	16
Oil Airplane Ridge Road Segment	1	D	18.75
Water Reinjection Pipeline	1	D	18.75
Water Reinjection Pump Stations	1	D	18.75
Transmission Corridor	1	D	18.75
Monitoring Facilities	1	D	18.75
Diversion Ditches	1	D	18.75
Shale Grouting Trench Test	1	D	18.75
Outslopes Scrubber Blowdown Ponds	3	D/H	25.0/50.0
Plant Site Slopes	3	H	50.0

1/ Seed Mixture - See Table 6-6-4

2/ D = Drill, H = Hydroseed

TABLE 6-6-4

Three Seed Mixtures Used for RBOSC Revegetation Activities

	Plant Species	Seeding Rate[1] (lbs PLS/acre)
Seed Mixture 1	Luna Pubescent Wheatgrass	2.5
	Western Wheatgrass	3.5
	Sodar Streambank Wheatgrass	2.0
	Indian Ricegrass	1.5
	Green Needlegrass	1.5
	Manchar Brome	1.5
	Cicer Milkvetch	1.5
	Madrid Yellow Sweetclover	0.75
	Lewis Flax	1.0
	Winterfat	1.0
	Fourwing Saltbush	1.0
	Bitterbrush	1.0
	TOTAL	18.75
Seed Mixture 2	Yellow Sweetclover	1.0
	Barley	1.0
	Western Wheatgrass	6.0
	Luna Pubescent Wheatgrass	8.0
	TOTAL	16.0
Seed Mixture 3	Yellow Sweetclover	4.0
	Crested Wheatgrass	8.0
	Barley	8.0
	Luna Pubescent Wheatgrass	5.0
	TOTAL	25.0

[1]/ Based on drilling rate; rate for broadcasting and/or hydroseeding is doubled.

TABLE 6-6-5

1981 Assessments of Areas Seeded in 1978

Area Seeded	Number of Transects	Growth Form	Planted or Invaded	Percent Cover
Soil Storage Pile	1	Grass	P	24.0
		Grass	I	--
		Forbs	P	--
		Forbs	I	6.6
		Shrubs	P	--
		Shrubs	I	--
			TOTAL	30.6
Water Reinjection System	3	Grass	P	13.9
		Grass	I	0.0
		Forbs	P	13.8
		Forbs	I	3.3
		Shrubs	P	1.2
		Shrubs	I	0.7
			TOTAL	32.9
Mine Service Area	7	Grass	P	12.4
		Grass	I	0.0
		Forbs	P	9.3
		Forbs	I	5.3
		Shrubs	P	0.6
		Shrubs	I	0.5
			TOTAL	28.1

TABLE 6-6-6
1980 Assessment of Areas Seeded in 1978[1]

Area Seeded	Number of Transects	Growth Form	Planted or Invaded	Percent Cover
Soil Storage Pile	1	Grass	P	32.7
		Grass	I	0.1
		Forbs	P	0.6
		Forbs	I	0.3
		Shrubs	P	--
		Shrubs	I	--
			TOTAL	33.7
Water Reinjection System	3	Grass	P	11.4
		Grass	I	0.1
		Forbs	P	18.5
		Forbs	I	4.7
		Shrubs	P	0.5
		Shrubs	I	1.1
			TOTAL	36.3
Mine Service Area	7	Grass	P	8.7
		Grass	I	--
		Forbs	P	12.1
		Forbs	I	3.0
		Shrubs	P	0.1
		Shrubs	I	0.2
			TOTAL	24.1

[1] Variations from data reported in the 1980 Annual Report are due in part to the loss of transects as areas were redisturbed.

The soil storage pile seeded in 1978 has coverage averaging 30.6 percent, most of which was from the seeded wheatgrass species. Invading forbs, primarily Russian thistle, accounted for most of the rest of the coverage. The Russian thistle coverage was high at two sampling points but was almost non-existent along the rest of the transect.

Coverage for this soil pile is lower than what was estimated in 1980 (33.7 percent) (Table 6-6-6). This difference is due to a decrease in the planted grass and planted forb categories. The soil pile was heavily grazed by cattle during the summer which may have been the cause for the decline in these two categories. The average coverage for invading forbs increased, however. Russian thistle increased from zero to 13 and 44 percent at two plots. This increase in Russian thistle coverage may be a result of the decrease in the planted grasses (wheatgrass species) and forbs, which probably was due to the cattle grazing. (NOTE: One transect was lost due to the addition of soil from the Lurgi access road to soil storage pile B).

Plant coverage on the water reinjection system areas was the highest of any area seeded in 1978 (32.9 percent, Table 6-6-5). Planted grasses (primarily the wheatgreass species, and to a lesser extent Manchar brome) and planted forbs (Lewis flax, cicer milkvetch, yellow sweetclover), accounted for 84.2 percent of this coverage.

Plant coverage along the corridors decreased from 36.3 recorded in 1980 (Table 6-6-6) to the present level of 32.9. This decrease is most evident in the planted forbs category. Yellow sweetclover, a biennial,

TABLE 6-6-7
1981 Assessment of Areas Seeded in 1979

Area Seeded	Number of Transects	Growth Form	Planted or Invaded		Percent Cover
Soil Storage Pile	1	Grass	P		30.7
		Grass	I		--
		Forbs	P		0.4
		Forbs	I		3.4
		Shrubs	P		--
		Shrubs	I		--
				TOTAL	34.5
Diversion Ditches	2	Grass	P		18.0
		Grass	I		--
		Forbs	P		5.3
		Forbs	I		4.2
		Shrubs	P		0.1
		Shrubs	I		0.1
				TOTAL	27.7
Access Roads	4	Grass	P		12.1
		Grass	I		0.1
		Forbs	P		9.7
		Forbs	I		2.0
		Shrubs	P		1.8
		Shrubs	I		0.1
				TOTAL	25.8
Mine Service Area	2	Grass	P		20.3
		Grass	I		--
		Forbs	P		8.5
		Forbs	I		2.8
		Shrubs	P		2.7
		Shrubs	I		--
				TOTAL	34.3

TABLE 6-6-8
1980 Assessment of Areas Seeded in 1979[1]

Area Seeded	Number of Transects	Growth Form	Planted or Invaded	Percent Cover
Soil Storage Pile	1	Grass	P	29.7
		Grass	I	0.5
		Forbs	P	0.2
		Forbs	I	24.4
		Shrubs	P	--
		Shrubs	I	--
			TOTAL	54.8
Diversion Ditches	2	Grass	P	13.7
		Grass	I	0.1
		Forbs	P	31.5
		Forbs	I	2.5
		Shrubs	P	--
		Shrubs	I	--
			TOTAL	47.8
Access Roads	4	Grass	P	7.5
		Grass	I	--
		Forbs	P	9.1
		Forbs	I	3.5
		Shrubs	P	2.0
		Shrubs	I	--
			TOTAL	22.1
Mine Service Area	2	Grass	P	8.5
		Grass	I	--
		Forbs	P	7.0
		Forbs	I	0.7
		Shrubs	P	0.7
		Shrubs	I	--
			TOTAL	16.9

1/ Values may be different than those reported in the 1980 Annual Report because of recalculations due to the loss of transects during redisturbance.

was the most prominent planted forb encountered in the 1980 survey but had decreased noticeably in 1981 due to die-off. Yellow sweetclover should again be more prominent in 1982. (NOTE: One transect was lost due to core hole drilling in the proposed open pit area).

Transects grouped under the mine service area category included those transects established on pond and mine site slopes, and in the equipment yard. Coverage in these areas was the lowest of the areas seeded in 1978, averaging 28.1 percent. As noted in previous discussions, the planted grasses (specificalty the wheatgrass species) and the planted forbs (primarily yellow sweetclover and, to a minor extent, Lewis flax and cicer milkvetch) accounted for most of this coverage. Russian thistle and Chenopodium species were responsible for the majority of the invading forb coverage. Grazing was evident on some of these fenced areas.

Coverage for the mine service increased from 24.1 percent in 1980 (Table 6-6-6) to the present level of 28.1. This increase was most dramatic in the planted grass category (i.e. a marked increase in the wheatgrass species). While the planted grass category increased in coverage, there was a drop in coverage for the planted forbs. This may be attributed to yellow sweetclover's biennial cycle.

6.6 STATUS OF ACREAGE SEEDED DURING 1979

The areas that were revegetated in May and November 1979 are listed on Table 6-6-2 and shown on the Areas Disturbed by Year May. Cover was

estimated as described in the previous section along 9 transects were grouped into four major categories (soil storage pile, diversion ditches, access roads, and mine service area). The cover values by growth form for each of these four categories are shown on Table 6-6-7.

Plant growth on the soil storage pile was the highest of any area seeded in 1979, averaging 34.5 percent. Planted grass species, specifically the wheatgrass species, accounted for 90.0 percent of this coverage. Invading forbs (primarily the Chenopodium species and, to a minor extent, Russian thistle) were responsible for most of the remaining plant coverage.

Average plant coverage declined drastically from 54.8 percent in 1980 (Table 6-6-8) to the present level of 34.5 percent. This decline was due to a substantial decrease in coverage of the Chenopodium species and Russian thistle at all but one plot. While the invading forb coverage was decreasing, there was a very slight increase at almost every plot for the planted grasses. With reduced competition from the invading forbs, this trend should be much more evident in upcoming years.

The diversion ditches seeded in 1979 had coverage averaging 27.7 percent. As in the previous discussion, the planted grasses (wheatgrass species) made up the bulk of this coverage. Planted and invading forbs accounted for almost all of the remaining coverage. Yellow sweetclover made up most of the planted forb coverage while Russian thistle (primarily at five plots along one transect) was the main invading forb.

There was a distinct decrease in plant coverage from 1980 (47.8 percent, Table 6-6-8) to 1981 (27.7 percent, Table 6-6-7). This decrease was almost solely in the planted forb category with yellow sweetclover responsible for this decline. The areas surveyed were planted in May 1979, allowing for the first year's growth that summer. Therefore, the yellow sweetclover was in its second year of growth (seed production) when coverage was assessed in 1980, with yellow sweetclover die-off seen during the 1981 season. While there was a decline in the planted forb coverage, the coverage for planted grasses and invaded forbs did increase; however, this increase was not nearly enough to off-set the sweetclover die-off. (NOTE: One transect was lost due to Phase III pond construction).

The lowest coverage value of the areas seeded in 1979 was on the access roads, where coverage averaged 25.8 percent. Planted grasses (primarily wheatgrass species) and planted forbs (yellow sweetclover and Lewis flax) accounted for most of the coverage. Almost all of the remaining coverage was from Chenopodium species (an invading forb) and from winterfat (a planted shrub).

There was a slight increase in average coverage from 22.1 percent (1980 assessment, Table 6-6-8) to 25.8 (1981 survey, Table 6-6-7). Most of this increase was due to an increase in the coverage of the planted wheatgrass species. (NOTE: Sand from the Access Road Sand Pit was needed for the Phase III pond construction resulting in a loss of two transects).

TABLE 6-6-9
1981 Assessment of Areas Seeded in 1980

Area Seeded	Number Of Transects	Growth Form	Planted or Invaded	Percent Cover
Soil Storage Piles	1	Grass	P	27.1
		Grass	I	0.3
		Forbs	P	7.6
		Forbs	I	0.2
		Shrubs	P	--
		Shrubs	I	--
			TOTAL	35.2
Water Injection System	3	Grass	P	17.4
		Grass	I	0.8
		Forbs	P	4.1
		Forbs	I	9.3
		Shrubs	P	--
		Shrubs	I	0.4
			TOTAL	32.0
Mine Service Area	7	Grass	P	10.6
		Grass	I	--
		Forbs	P	19.6
		Forbs	I	1.2
		Shrubs	P	--
		Shrubs	I	--
			TOTAL	31.4

Transects located on pond outslopes were grouped under the mine service area category. Coverage on these pond slopes averaged 34.3 percent, with the planted grasses and forbs accounting for 84.0 percent of this coverage. The dominant planted grasses were wheatgrass species, and Lewis flax and yellow sweetclover accounted for most of the planted forb coverage. The remaining coverage results equally from the invading forbs (Chenopodium species) and with winterfat, a planted shrub. Winterfat was prevalent along one transect but was nonexistent on the other transect. Even though the area is fenced off, grazing was evident.

The average plant cover significantly increased in the two years of assessment on these permanent transects. Coverage in 1980 was 16.9 percent but jumped to 34.3 percent in 1981. The majority of this increase, as in the previous discussion, was due to the dramatic increase in coverage of the planted grasses, primarily wheatgrass species (from 8.5 to 20.3 percent). Minor increases in coverage were evident in the case of the invading forbs and the planted shrubs.

6.7 STATUS OF ACREAGE SEEDED DURING 1980

The areas that were revegetated in October and November 1980 are listed on Table 6-6-2 and illustrated on the Areas Disturbed By Year Map. Cover was estimated as described in the previous sections along five transects established in these seeded areas. For reporting purposes, these transacts were grouped into three categories (soil storage pile,

water reinjection system, and mine service area). The cover values by growth form for each category are shown in Table 6-6-9.

Plant growth on the soil storage pile was the highest of any area seeded in 1980, with cover averaging 35.2 percent. Planted grasses, most notably the wheatgrass species and to a minor extent Manchar brome, accounted for 77.0 percent of this coverage. Yellow sweetclover, a planted forb, was responsible for almost all (21.6 percent) of the remaining coverage.

Cover along the water reinjection system was good, averaging 32.0 percent. Planted grasses and invading forbs accounted for the majority of this coverage. The primary planted grass species present was annual ryegrass, which was planted for the first time on Tract C-a during 1980 for stubble mulch purposes. This grass should be out-competed in the coming years. The other most prevalent planted grasses were the wheatgrass species. Chenopodium species, the most notable invading forb, was prevalent throughout one transect but was almost nonexistent on the other transects.

The area with the lowest coverage among those seeded in 1980 was the mine service area, with the transects on pond outslopes. Coverage on this area averaged 31.4 percent. Yellow sweetclover (a planted forb) and the wheatgrass species (planted grasses) accounted for 95.2 percent of this cover. Grazing was not evident on this fenced area.

6.8 STATUS OF ACREAGE SEEDED DURING 1981

Seeding success for areas seeded in 1981 was not determined due to late fall seeding. However, permanent transects will be established in these areas and seeding success will be determined after the 1982 growing season.

Subsidence Monitoring

In June and December of 1981, the subsidence monuments located on the surface above the retorts and other areas were surveyed for horizontal and vertical movement. No horizontal or vertical movement was detected. Issues 10 and 11 of the maps showing the subsidence monitoring were sent to the Oil Shale Office.

8.1 INTRODUCTION

The Tract C-a lease environmental stipulations require RBOSC to avoid, minimize, and/or mitigate damage to fish and wildlife habitat. Section Four of the environmental stipulations requires RBOSC submit:

> "a detailed fish and wildlife management plan which shall include the steps which the Lessee shall take to: 1) avoid or, where avoidance is impracticable, minimize damage to fish and wildlife habitat, including water supplies; 2) restore such habitat in the event it is unavoidably destroyed or damaged; 3) provide alternate habitats; and 4) provide controlled access to the public for the enjoyment of the wildlife resources on such lands as may be mutually agreed upon. The plan shall include, but not be limited to, detailed information on activities, time schedule, performance standards, proposed accomplishments, and ways and means of avoiding or minimizing environmental impacts on fish and wildlife" (p.A-17).

The Fish and Wildlife Management Plan presented in this chapter describes RBOSC's efforts to meet this requirement. RBOSC is committed to mitigating, to as great an extent as possible, the potential adverse impacts to fish and wildlife resulting from project activities.

It should be pointed out, however, that the absence of any sizable water body proximal to Tract C-a precludes direct impact on a fisheries resource due to MIS activities. Any future off-tract RBOSC activities will be monitored for any potential effect on fisheries resources.

To satisfy the above lease stipulations, RBOSC, with the cooperation of Federal and State officials, is presently concentrating on maintaining and increasing local populations of mule deer, the principal wildlife species in the area. Benefits to livestock and other wildlife will probably result, but the program is directed specifically to benefit mule deer. The program is divided into three efforts 1) mule deer habitat modification; 2) habitat restoration; and 3) human disturbance control.

8.2 WILDLIFE HABITAT ENHANCEMENT

The critical factor which currently limits mule deer populations in the Piceance Creek Basin is the availability of food during periods of heavy snow cover. Thus, one of RBOSC's programs is designed to increase the carrying capacity of local habitats for mule deer in the area by increasing forage as well as providing access for mule deer to the modified area during periods of heavy snow cover. Habitat modification in large, continuous blocks increases wildlife forage, but such large areas commonly fill with snow during severe snow periods, making the area inaccessible to deer. The RBOSC habitat modification program is designed to avoid this problem by modifying vegetation in strips, leaving the vegetation between the strips undisturbed. The undisturbed strips provide cover and access routes to the modified areas.

The first phase of the habitat modification program was initiated in the fall of 1980 on an experimental basis in a limited area (Figure 6-8-1).

The program is designed to evaluate the effects of several factors critical to increasing deer carrying capacity 1) snow depth; 2) moisture availability during the growing season; 3) brush removal; 4) quality forage; and 5) fertilization.

Decadent sagebrush in a small valley at some distance from tract activities was removed in narrow, parallel strips separated by non-altered sagebrush. Two sets of strips were formed, using a tractor-towed rotochopper. One set is oriented along the axis of most winter winds; the other set is perpendicular to winter wind direction. A differential accumulation of snow should occur from one set to the other. Various combinations of planting of favorable deer forage and applications of fertilizer were also incorporated to provide a range of treatment regimes. Control (untreated) areas were also located near each of the treatment areas.

The success of the habitat modification portion of the Fish and Wildlife Management Plan will be ascertained through monitoring of vegetative composition and productivity, and utilization of vegetation by mule deer. Specific monitoring activities include:

- Range composition and productivity analyses
- Pellet group analyses
- Photographic monitoring of deer distribution between treatment and control areas.

These monitoring activities are designed to determine if the habitat modification program results in a statistically significant difference in mule deer forage and/or mule deer utilization between the treated and

control areas. The effects of various treatment factors such as aspect, strip orientation, and seed/fertilizer application will also be determined through comparisons within the modified areas. An optimum treatment regime will be identified, provided that the results of the modifications are positive.

If the experimental habitat modification program produces positive results, the program may be expanded to larger areas. A tentative proposal involves application of the program to one of the large (approximately nine square miles) blocks used to monitor mule deer density as part of RBOSC's ongoing terrestrial ecology monitoring program (see Section 7, Chapter 3 of this document). Baseline data on mule deer density and distribution among these blocks are available. These data could provide a reference for analyzing the effects of the habitat modification program on the densities and distribution of mule deer on a large scale. RBOSC will work closely with the CDOW, the OSO, and BLM in the development and application of any such habitat modification program.

8.3 WILDLIFE HABITAT RESTORATION

Project-related activities result in temporary loss of wildlife habitat due to disturbance. These disturbed areas are reclaimed as described in Section 6, Chapter 6 of this document. Reclamation involves recontouring, replacing topsoil, and revegetating disturbed areas. Wildlife requirements were considered in developing the RBOSC

reclamation plan. Seeding composition and rate are designed to provide vegetation communities similar to the pre-disturbance communities, so that the reclaimed area can support numbers and species of wildlife similar to the pre-disturbance wildlife community in a timely manner and in accordance with lease stipulations. RBOSC evaluates reclamation success on a yearly basis. The results of the 1981 reclamation success survey are presented in Section 6, Chapter 6 of this document.

Another part of the RBOSC wildlife habitat restoration program involves the experimental construction of wildlife habitat. As a supplement to the reclamation activities mentioned above, RBOSC is constructing a south-facing bench designed to simulate the benches which will be required on any large mine site and/or disposal pile reclaimed slope (Figures 6-8-1 and 6-8-2). This bench test is designed to enable an evaluation of the feasibility of harvesting run-off water to enhance shrub growth for wildlife cover. Other factors which will evaluated are 1) overburden reclamation success; 2) moisture passage through and storage in typical overburden; 3) topsoil loss on south facing slopes; 4) effect of summer irrigation on shrub growth; and 5) palatability of certain shrubs to deer.

Several years of data will be required before the results of this test can be meaningfully assessed. Initial data will be gathered in the Fall of 1982. Information from this bench test will be used in the design and reclamation of mine site dispodal pile, and other slopes to ensure the establishment and long life of quality wildlife habitat.

8.4 HUMAN DISTURBANCE CONTROL

The human activity associated with the development of Tract C-a has the potential of adversely impacting the wildlife of the project area. These potential adverse impacts include increased wildlife mortality due to roadkill and/or increased hunting pressure (legal and illegal) as well as increased wildlife harassment due to off-road vehicle use and/or disturbance by humans or their pets. RBOSC mitigates these potential impacts through a combination of education efforts and employee regulations.

A slide show which discussed driving habits which reduce the likelihood of roadkill of the important wildlife species of the Tract C-a area has been developed for employees and visitors. Speed limits are posted in the project area, and deer crossing signs have been placed in appropriate areas.

Potential adverse impacts due to excessive hunting pressure are mitigated by distribution and posting of information concerning hunting and trapping regulations. Hunting and trapping on restricted portions of the project area are prohibited. RBOSC will consider the conviction of any employee for job-related game violations as grounds for disciplinary action.

A brochure which describes the undesirable safety and ecological aspects of off-road vehicle use has been developed for employees and visitors. The potential adverse wildlife impacts caused by the presence of people

and their pets are also discussed in the brochure. Harassment of wildlife by RBOSC employees or their pets is prohibited. All vehicles are restricted to designated roads, construction areas, and disposal areas; barriers have been erected to prevent traffic through sensitive wildlife areas. Impacts are further reduced by using buses to transport the majority of the work force to and from the project area.

In addition to implementing the programs which have been described, RBOSC will comply with all of the stipulations of the Tract C-a Oil Shale Lease which address fish and wildlife concerns. In response to one of these stipulations, RBOSC has installed devices on all newly constructed powerlines to prevent raptor electrocution.

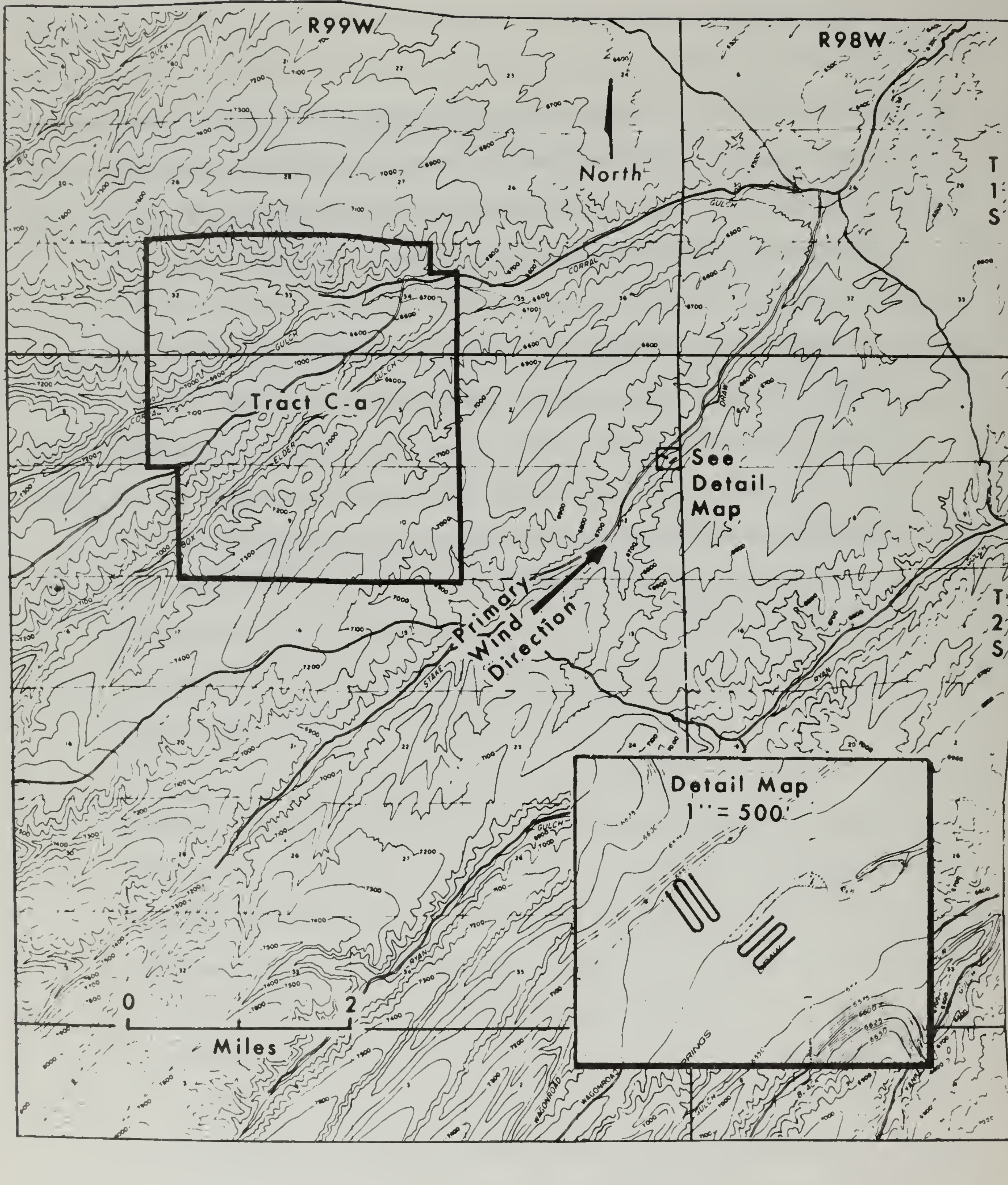


Figure 6-8-1. Location of Mule Deer Habitat Modification Study

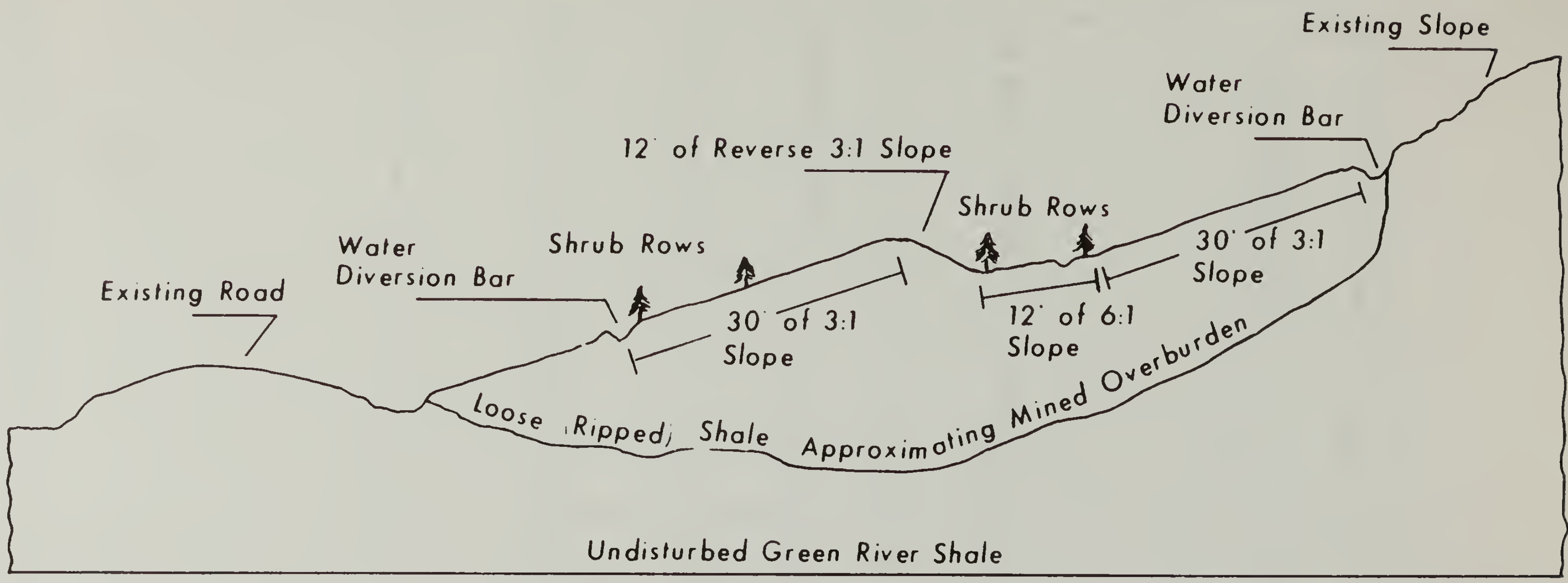


Figure 6-8-2 Cross Section of Simulated Mine Bench for Testing of Shrub Growth through Water Harvesting.

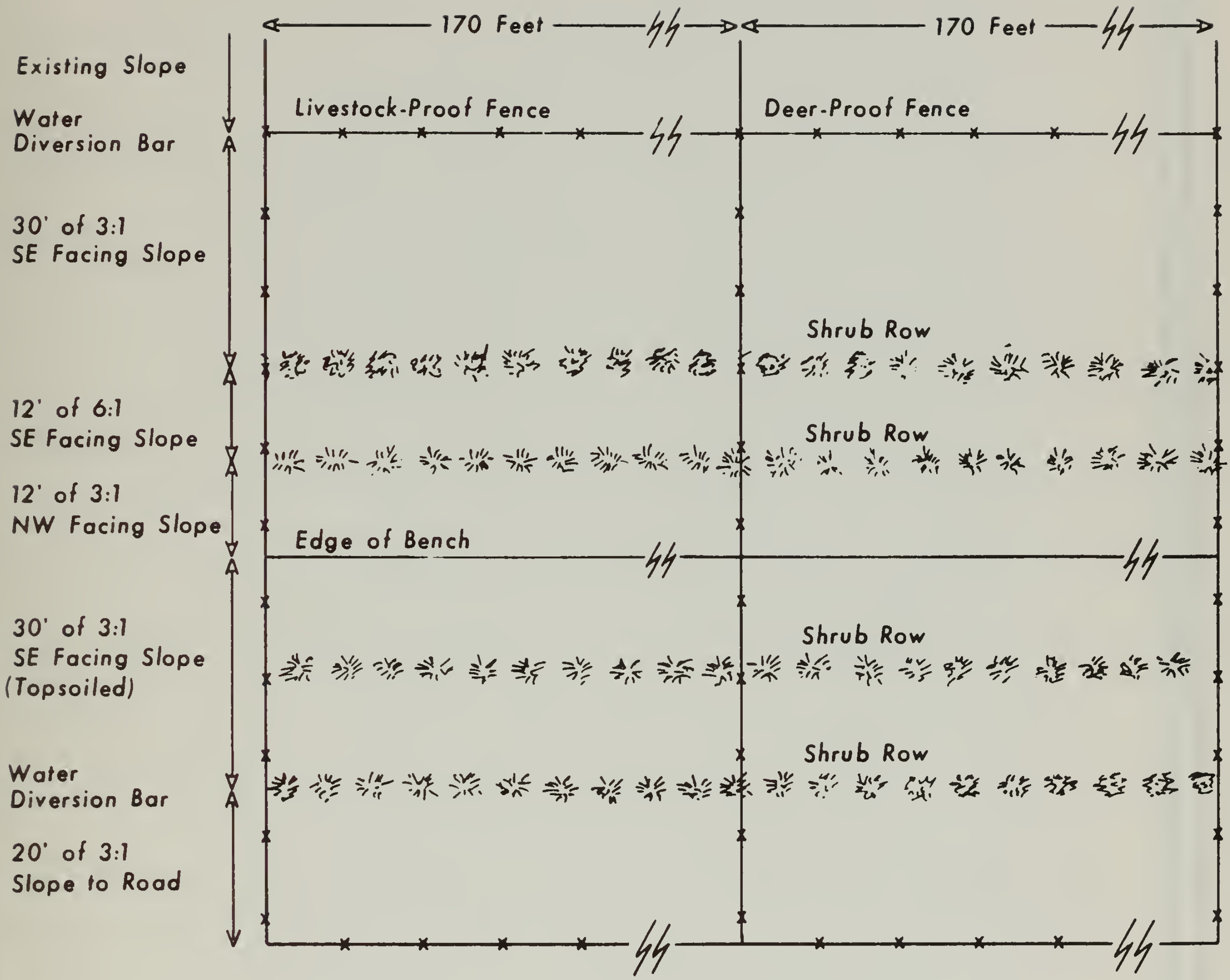


Figure 6-8-3. Aerial View of Simulated Mine Bench for Testing Enhancement of Shrub Growth through Water Harvesting.

SECTION VII

SUMMARY—ENVIRONMENTAL ASSESSMENT & MONITORING

CHAPTER 1
INTRODUCTION

The United States Department of the Interior/Geological Survey (USGS) initiated planning in 1969 for a prototype oil shale leasing program. Under this program, Gulf Oil Corporation and Standard Oil Company (Indiana) acquired the rights to Federal Oil Shale Lease Tract C-a in the Piceance Basin in northwest Colorado in 1974. These two companies are developing Tract C-a under a general partnership called the Rio Blanco Oil Shale Company (RBOSC).

RBOSC has been engaged in extensive environmental data collection programs since its inception in 1974. Environmental baseline data were gathered between October 1974 and September 1976. An interim environmental monitoring program was conducted between September 1976 and August 1977, the period during which the Tract C-a lease was suspended. RBOSC initiated the Modular Development Phase (MDP) of tract development and the MDP Environmental Monitoring Program in August of 1977.

The MDP Environmental Monitoring Program is designed to provide data on air quality, meteorology, visibility, terrestrial ecology, aquatic ecology, hydrology, and specialized topics including ecological interrelationships. The program is designed based on the environmental stipulations in the Tract C-a lease, analysis of baseline and interim monitoring data, assessment of probable development impacts, and inputs form the USGS Oil Shale Office (OSO). Monitoring is conducted according to the MDP Environmental Monitoring Program Scope of Work (SOW), the current version of which (Revision 6.1) is dated February 25, 1981 and was approved by the OSO May 1, 1981, with four conditions of approval.

Data collected through the MDP Environmental Monitoring Program are reported semi-annually, in a mid-year and a year-end report to the OSO. The first MDP monitoring report (Modular Development Phase Environmental Monitoring Report One or MDP 1) was published in February 1978. Subsequent reports were published in September 1978, March and August 1979, March and August 1980, and March and August 1981. This report is the ninth MDP Monitoring Report (MDP 9), and is the fourth year-end report. The MDP 9 report covers the 1981 reporting year (December 1, 1980-December 31, 1981). The report contains presentations and summaries of 1981 reporting year data; statistical comparisons between seasons, years, and locations; and assessment of any development-related impacts. Sections of the report generally address objectives, methods, results and discussion, and summary and conclusions. Methods are referenced rather than fully described unless they are different from those employed in previous monitoring periods, need clarification, or have not been previously reported.

Major responsibility for implementation of the MDP monitoring program and preparation of the MDP reports rests with the staff of the RBOSC Environmental Affairs Department. Several other individuals and entities assisted un monitoring activities during the 1981 reporting period and in preparation of MDP 9, however. They include the following:

Morrison-Knudsen and the Industrial Company (TIC) (Operational Hydrology Monitoring)

Mariah Associates (Aquatic Ecology Sample Analysis and Report Preparation)

U.S. Geological Survey (Surface Water Gaging Station Data)

Dr. J. S. Warner (Statistical Review)

Cathedral Bluffs Oil Shale Venture (Visibility Monitoring)

Volume one of MDP 9 contains the following major sections:

Section 1	Introduction
Section 2	Atmospheric Studies
Section 3	Terrestrial Studies
Section 4	Aquatic Studies
Section 5	Hydrology Studies
Section 6	Special Studies/Ecological Interrelationships

Volume two through four of MDP 9 contain the following appendices:

Appendix 2-1	Air Quality Data
Appendix 2-2	Meteorological Data
Appendix 2-5	Visibility Data
Appendix 3-1	Vegetation Data and Analyses
Appendix 3-2	Fauna Data and Analyses
Appendix 4-1	Aquatic Biotic Data

Appendix 4-2	Aquatic Biotic Data and Analyses
Appendix 5-1	Dewatering/Reinjection/Discharge Hydrological Data and Analyses
Appendix 5-2	MIS Modular Development Area Hydrological Data and Analyses
Appendix 5-3	Lurgi Site Hydrological Data and Analyses
Appendix 6-1	Experimental Revegetation Data and Analyses
Appendix 6-4	Mule Deer Habitat Modification Data and Analyses
Appendix 6-6	Range Enclosure Data and Analysis

Both air quality and meteorological data were collected during the reporting period. The major event affecting air quality within this period was the burning of Retort 1 from June to December. The maximum concentration of SO_2 (the major air pollutant of concern released from the retort) measured during the burn was 0.047 ppm at Site 1. Since this SO_2 concentration was measured under easterly winds (which would transport the stack emissions in the direction of Site 1), it is quite likely that this measurement resulted from the Retort 1 burn. Apparently, SO_2 emissions from the retort are not transported into Corral Gulch, because no values of SO_2 above the background level were detected at Site 3 during the Retort 1 burn.

A supplementary SO_2 monitoring program using grab bag samples was carried out during October, when emissions from the retort were temporarily diverted from the emissions control system to the flare stack. (A detailed report of this program is given in Section 6.7). The highest SO_2 concentration measured during this supplementary monitoring was 0.12 ppm (260 H/m^3). This is one-half of the 3-hr Class II increment, but is not directly comparable because this was an instantaneous grab bag sample. SO_2 concentrations at the same location were 40 percent of this value an hour earlier, and near background levels an hour later.

The ozone concentrations found in the vicinity of the tract varied from 0.001 to 0.073 ppm, well below the National Ambient Air Quality Standard (NAAQS) for ozone of 0.12 ppm. The diurnal cycle of ozone concentrations at Site 3 was greater than at Site 1. The larger cycle

at Site 3 results from nighttime inversions which develop within the gulch in which Site 3 is located. The inversions effectively seal off the gulch from exchange with the rest of the atmospheric boundary layer, allowing ozone destruction reactions to reduce the ambient ozone concentrations at night.

The source of the relatively high ozone concentrations measured at the tract has not been definitely identified, although these concentrations have been found to be typical of many other remote locations. There has been no evidence of local photochemical production from either natural or anthropogenic sources.

Total suspended particulates (TSP) did not exceed the NAAQS during the current year. Multiple and stepwise regression analyses were carried out on the particulate data, using a combination of meteorological and site activity variables. The highest correlations were found using the annual rather than the seasonal TSP data sets. Approximately two-thirds of the variability of TSP concentrations in the annual data sets could be explained by the meteorological and site activity variables. This is very similar to the results of regression analyses performed for the three previous years.

Site activity parameters ranked no higher than third in explaining the variability of TSP concentrations, and contributed only minor improvements to the regression analyses. Temperature was by far the most successful predictor, largely because it has an annual cycle

similar to the TSP data, and it serves as an indicator variable for other important parameters, such as soil moisture.

Review of the meteorological data from the current year revealed that 1981 was slightly warmer and considerably wetter than previous years. Precipitation at the tract totalled approximately 17 inches during the current year. The annual temperature range of 50 C (-20 C to +30 C) measured during the current year at Site 1 is typical of continental sites. Wind speed at the tract has been relatively low, reaching a maximum of 26 mph at the 10-m level at Site 1. Winds have been predominantly out of the west and southwest.

The 1981 visibility monitoring program indicated a slight increase in visual ranges in the Piceance Creek Basin. The mean annual visual range during 1981 was 86 miles, which compares with visual ranges of 85 miles measured in 1980, and 79 and 80 miles measured during the three earlier years of monitoring. There is a large day-to-day variability in the visual range, but this is primarily a result of widely varying meteorological conditions. The maximum visual range measured in 1981, 175 miles, was the second highest value in the five years of monitoring. Visual ranges of at least 142 miles have been recorded during each of the years. These values approach the theoretical limit of visual range in the atmosphere.

Two noise surveys were taken during the reporting period. The measured sound levels generally ranged from less than 30 dBA (the threshold of the instrument) to 50 dBA, except hear the main construction are

(adjacent to the headframe), which averaged 67 dBA. If the measurements taken near the main construction area are excluded, these sound levels are comparable to data taken during the baseline period.

The components of the Terrestrial Monitoring Program examined during the 1981 reporting period include vegetation type mapping and stress, browse condition and utilization, phytosociology, range production and utilization, small mammal, avifauna, mule deer, and feral horse studies.

The distribution of plant communities during 1981 was compared with that established during baseline studies and as a result of analysis of 1978 color aerial photographs. Changes noted on Tract C-a and within a five mile perimeter are the result of oil and gas exploration as well as Tract C-a related construction including the airstrip, the road to off-tract property, coreholes, and the dewatering/reinjection system. Small amounts of Pinyon-Juniper and sagebrush vegetation have been affected by these activities but no major changes in plant community distribution have resulted from activities other than construction related to Tract C-a development. Analysis of 1981 color infrared photographs is not complete; consequently, results will be reported in subsequent MDP Monitoring Reports.

Browse studies indicated that the weighted average percent utilization ranged from 5 percent in the sagebrush to 9 percent in the Pinyon-Juniper vegetation type. Utilization increased in the Mixed Brush and sagebrush types but decreased slightly in the Pinyon-Juniper habitat type relative to 1980 data. Results of a two-way ANOVA using arcsine transformed estimates of leader utilization among years (1978-1981) by individual browse species indicated significant differences ($=$ 0.025) in use of serviceberry (Amelanchier utahensis) within the Mixed Brush type; sagebrush (Artemisia tridentata), pinyon

pine (Pinus edulis), bitterbrush (Purshia tridentata), mountain mahogany (Cercocarpus montanus), snowberry (Symphoricarpos oreophilus), and serviceberry within the Pinyon-Juniper type; and sagebrush within the sagebrush vegetation type. For the most part, all of these species experienced significantly lower browse leader usage in 1981 than during 1978. This lower leader use in 1981 relative to 1978 is probably a result of the decline in the mule deer herd due to the harsh 1978-79 winter.

Range condition ratings based on hedging class are for the most part an improvement over what was exhibited in 1980. These meliorations are due to lower browse utilization over the years. Because the RBOSC browse studies are designed to census the same shrubs every year, any large changes in range condition ratings based on hedging class would not be found. However, analyses of these data over years should show trends in range condition ratings.

Phytosociological studies were conducted within the Pinyon-Juniper and sagebrush vegetation types in Treatment Area 7, which is located just east of RBOSC's off-tract land. Average coverage of trees and shrubs within the Pinyon-Juniper habitat type was 44.2 percent. Pinyon pine (Pinus edulis) and juniper (Juniperus osteosperma) accounted for almost all of this cover. Sagebrush (Artemisia tridentata) had the highest average density (1,100 stems pe hectare) of any tree or shrub surveyed in the Pinyon-Juniper area (density averaged 1,953 stems per hectare for woody species). Herbaceous coverage averaged 16 percent, with grasses accounting for 12.3 percent and forbs 3.7 percent of this total.

Dominant grasses were bluegrass (Poa) and wheatgrass (Agropyron) species while Hood's phlox (Phlox hoodii) and Cryptantha sericea were the most prevalent forbs. Statistical comparisons of arcsine transformed coverage estimates for grasses and forbs showed no significant differences among transect within Area 7 (= 0.05).

Coverage of trees and shrubs in the sagebrush vegetation type averaged 22.3 percent while average density was 11.287 stems per hectare. Sagebrush was the most prominent species, averaging 20.5 percent cover and 9,573 stems per hectare. Douglas rabbitbrush (Chrysothamnus viscidiflorus) was a subordinate shrub, averaging 1,280 stems per hectare and 1.4 percent cover. The grassforb stratum averaged 30 percent coverage. Grasses, primarily the bluegrass, wheatgrass, and needle-and-thread (Stipa comata) species, accounted for 21.7 percent of this total cover. Forb coverage was 8.4 percent most of which was made up by Hood's phlox and, to a lesser extent, scarlet globemallow (Sphaeralcea coccinea) and Cryptantha serica. As in the Pinyon-Juniper discussion, there were no significant differences (= 0.05) for the arcsine transformed grass and forb coverage date in the sagebrush habitat type among transects within Area 7.

Range productivity and utilization studies indicated that production ranged from 106.6 kg/ha in the Pinyon-Juniper vegetation type to 440.8 kg/ha in the Mixed Brush type. With the exception of the Pinyon-Juniper type, forb production exceeded grass production. Wheatgrass (Agropyron) species, Indian ricegrass (Oryzopsis hymenoides) and bluegrass (Poa) species were the dominant grasses in all three vegetation types. For

the most part, forb species responsible for the majority of the production were similar for all three habitat areas. Hood's phlox (*Phlox hoodii*), stemless goldenweed (*Haplopappus acaulis*), bastard toadflax (*Comandra umbellatum*), and sulfur eriogonum (*Erigonum umbellatum*) were predominant on the Mixed Brush area. The Pinyon-Juniper habitat type was dominated by *Cryptantha sericea*, stemless goldenweed, and Hood's phlox. The dominant forb species within the sagebrush vegetation type was Hood's phlox.

Statistical comparisons of range production among 1981 transects within the three vegetation types indicate significant differences (= 0.025) for forb production within caged plots in the Pinyon-Juniper habitat type, and for grass and forb production within caged plots in the sagebrush vegetation type. Comparisons among years (1978-1981) using a two-way ANOVA indicate significant differences in grass production for caged and uncaged plots in all three vegetation types. An exception was grass production within caged plots in the Mixed Brush habitat type. Grass production in 1981 was significantly greater than during 1978 in all of the vegetation types.

Utilization of the Mixed Brush and sagebrush vegetation types declined in 1981 when compared to previous years. Within the Mixed Brush type, usage declined from a three year high of 31 percent recorded in 1980 to 22 percent in 1981. Utilization in the sagebrush vegetation type decreased from 40 percent in 1980 to 32 percent in 1981. Utilization for the Pinyon-Juniper area could not be determined because of a higher total herbaceous production in uncaged than in caged plots. This

appears to be due to an extremely inflated forb production caused by stemless goldenweed (Haplopappus acaulis) (176.8 g/m^2 (1,768 kg/ha) on one uncaged plot). If stemless goldenweed is excluded from the uncaged plots (it was not encountered on any caged plots), the total production in uncaged plots is lower than that for caged plots. The result is a 12 percent usage, which is comparable to use in the previous two years.

Small mammal trapping studies were conducted in 1981 in sagebrush and Pinyon-Juniper habitats in control and treatment study areas on and near Tract C-a. These studies are designed to determine the species presence and habitat affinity, and to provide indices of relative abundance of dominant small mammal species.

In 1981, the deer mouse (Peromyscus maniculatus) continued to be the most frequently captured species in all trapping locations. The least chipmunk (Eutamias minimus) continued to be the second most frequently captured species in Treatment Area 5 and Control Area 6. Other species captured in 1981 were the golden mantled squirrel, the pinyon mouse, and the sagebrush mole. The limited species diversity may be a function of habitat qualities, trap affinities of the various species, or a combination of both. Species diversity has remained rather stable in Area 5 and Area 6 for three years. The yearly variation in the number of captures of dominant species in Area 5 and Area 6 is within the expected range due to normal fluctuation in small mammal populations. The reason for the low capture rate for all species in Treatment Area 7 is unknown. Phytosociological differences do not appear to be great

enough to account for the differences between the small mammal capture rate in Area 7 and those in Areas 5 and 6.

The objectives of the avifauna program are to determine the presence, habitat affinity, relative density (number observed per hectare of habitat), and relative abundance of avifauna species in sagebrush and Pinyon-Juniper habitats within control and treatment areas.

Avifauna sightings have changed little since initiation of sampling in 1979. Not all species are observed in all years. Most of the species seen infrequently are not abundant in the region and/or are not common to the habitat types being surveyed.

Species indicative of the Pinyon-Juniper habitat type are the Mountain Chickadee, Mountain Bluebird, and Black-throated Gray Warbler. Densities of these species have varied among the sample years, with the numbers of some species declining and others increasing. The Pinyon-Juniper habitats are somewhat dissimilar in the three areas in which avifauna are censused (see Section 3.1C of this report). These dissimilarities may account, in part, for the different species observed in the three study areas. These differences are typical and expected when comparing geographic areas. Common species in the sagebrush habitat are the Green-tailed Towhee and Brewer's Sparrow. Overall densities of avifauna species in the sagebrush habitats are very similar among the study areas for the years sampled.

The high variability of avifauna populations from year to year precludes drawing any firm conclusions regarding the effect of tract development on avifauna.

The objectives of RBOSC's mule deer monitoring program are to obtain indices of mule deer density in a study area centered on Tract C-a, to compare those indices with those from CDOW Game Management Unit 22 and, if possible, to compare differences in mule deer densities within various portions of the study area.

The deer density estimates for 1981 and previous years show an overall decline in winter use of the study area since the counts were initiated in 1978. The Piceance Basin deer herd was fairly large in the fall of 1978, and the ensuing winter caused severe deer mortality. As much as one half of the deer herd, including 80-90 percent of the fawns born in 1978, was lost to starvation and exposure in the winter of 1978/79 (John Gray, CDOW, personal communication). Analyses of the mule deer density data collected to date indicate that populations are beginning to rebound from this low point, however. Analysis of winter density indices for the four years sampled to date reveals that, although average densities continued to decline in 1981, this decline was not statistically significant. Densities had declined significantly for two consecutive years prior to 1981.

Evidence that deer populations are increasing can be found by examinations of 1981 mule deer density data as well. Limited snow accumulation during the winter of 1980-81 allowed the deer to winter at

elevations which were higher than normal, resulting in a reduction of use of the study area. Consequently, density estimates for 1981 may have been somewhat depressed. This theory is substantiated by the fact that winter density estimates were higher in 1981 than in 1980 in only three blocks within the study area: blocks 1, 4, and 7. These blocks are at higher elevations than the rest of the blocks and are near summer range. The regional deer population thus may have been higher than indicated by the 1981 indices.

Considering the efforts of winter conditions on mule deer movements and overall herd stability, the impacts resulting from the development activity on Tract C-a to date on mule deer are difficult to assess. Continued data collection and scrutiny should yield more information on deer behavior in the western Piceance Basin, and increase the feasibility of identifying any development-related impacts.

The objective of the mule deer road kill survey is to determine mule deer mortality due to collisions with vehicles along Rio Blanco County Road 24, from the Piceance Creek Road to Tract C-a. Ten road kills were observed in 1981. Even though deer densities along County Road 24 varied greatly from 1979 to 1981, the number of road kills did not. It is likely that some deer road kills always will ne associated with heavy traffic in areas of high deer density.

Feral horses occur on and in the vicinity of Tract C-a. The objective of the feral horse monitoring studies is to provide qualitative information concerning the status of feral horses in the RBOSC study

area. Feral horses were counted from a helicopter in March 1981. Ten bands of horses totaling 57 individuals were observed. This number is less than the 99 horses observed in the 1979 count and the 120 observed in 1980. The BLM conducted horse roundups throughout the Piceance Basin in September of 1980. This is probably the reason for the reduction in the number of horses observed in March 1981. Another factor in the reduced count may have been the limited snow cover during the census period, which allowed the horses to move to higher elevations outside the study area. Foal success was determined by a road count survey separate from the aerial survey. Foal success was apparently similar for 1980 and 1981.

Physical parameters examined at each of the aquatic sampling stations indicate seasonal as well as annual variability. Few trends or major changes in the physical measurements could be detected from the data. Station CG-1 experienced an increase in flow as compared with baseline conditions.

Water quality measurements made in 1981 indicated no significant changes in White River water quality upstream from its confluence with Yellow Creek, except for a possible increase in TDS at Station WR-2 in October. Examination of the 1981 data for the stations on Corral Gulch and Yellow Creek indicates a general and substantial downstream increase in dissolved solids.

Annual variations in periphyton densities occur on a seasonal basis and are directly related to such highly variable environmental parameters as current velocity, temperature, light, spring runoff, turbidity and substrate type. The 1981 density estimates at Station CG-1 were lower than the baseline values, and changes in species composition indicate a slightly higher organic load. Changes in species dominance over time at this site could be naturally induced since such changes are not uncommon in aquatic habitats like Corral Gulch, which exhibits a high degree of variability in environmental parameters.

Station YC-3 on Yellow Creek has spring and fall periphyton communities which appear to be dominated by a group of diatoms whose relative abundance varies annually. There has been an increasing summer trend of

green algal dominance at Station YC-3 during the MDP monitoring studies from 1978 through 1981.

Station WR-1 on the White River, upstream from any project influence, has shown changes in periphyton density and species diversity similar to Station WR-2, which is on the White River downstream from the confluence of Yellow Creek. Therefore, it appears that Tract C-a project activities have little or no effect on the periphyton communities of the White River.

The macroinvertebrate fauna at Station CG-1 are characteristic of the fluctuating conditions common to small streams in semiarid regions. Station CG-1 is located in an unstable area characterized by changing flow and turbidity. As might be expected under such conditions, seasonal changes in macroinvertebrate densities occurred at this station in 1981. The low densities in July are probably attributable to the flash flood which occurred just prior to sampling. There was no discharge of water from project dewatering activities during 1981, so it is likely that other seasonal changes observed at the station in 1981 were due to natural causes.

Yellow Creek is a small creek also affected by natural fluctuations in hydraulic and water quality parameters. The upper Yellow Creek station, YC-1, showed similarities to Stations YC-2 and YC-3 on lower Yellow Creek have similar macroinvertebrate communities characterized by organisms tolerant of unstable flow and turbidity conditions.

The White River does not appear to have been directly affected by operations on Tract C-a. The macroinvertebrate communities at Station WR-1 and WR-2 can be described as normal for a western stream the size of the White River; however, they are substantially more diverse and stable than the communities of Corral Gulch and Yellow Creek.

The hydrology monitoring program collects information for several needs:

- Stipulations of the lease and conditions of approval from OSO
- Engineering design input for mine and water handling system
- Evaluation of the need for environmental mitigative measures
- Permit requirements

The program includes monitoring at numerous installations, including stream gaging stations, springs and seeps, erosion and sedimentation stations, alluvial and deep aquifer wells, surface impoundments, surface discharges, reinjection system, and dewatering wells. The natural hydrologic and hydrogeologic environment as well as facilities associated with tract development are monitored.

During 1981, the hydrology monitoring program was modified to focus on four proposed major development activities on Tract C-a (RBOSC 1981):

1. Dewatering/Reinjection/Discharge Program
2. MIS Modular Development Area
3. Open Pit
4. Lurgi Plant Site

The discussion of the 1981 monitoring program is divided into three sections, corresponding to above-listed items 1, 2, and 4. The development of the open pit and hence monitoring of this activity has been deferred and will not be considered in this report. The Lurgi plant site construction has also been deferred but some collection of

background data was included in the 1981 monitoring effort and is considered in this report.

Hydrology monitoring stations have been classified as follows:

- Type I - control stations not expected to be influenced by a given set of development activities
- Type II - expected to exhibit direct, short-term impacts, should impacts result from development; such stations are located generally downgradient in near-field area relative to development
- Type III - expected to exhibit indirect or long-term impacts; should impacts result from development; such stations are located downgradient from development in far-field areas.

Grouping stations allow for spatial as well as temporal comparison of water quality and physical parameters. Thus "pre- and post" development levels and the "control vs potentially affected" areas can be compared.

A. Dewatering/Reinjection/Discharge Program

The dewatering/reinjection/discharge program focuses on monitoring for changes in ground water levels and surface flows. The cone of depression from the dewatering operation was relatively stable throughout 1981. Dewatering was accomplished through dewatering wells and mine sumps until late November 1981 when the use of dewatering wells

was terminated. Dewatering flows were all reinjected or consumed in 1981; no water was discharged at the surface from this operation.

This mean concentrations of dissolved constituents in the composite reinjection water during 1981 were generally similar to that of 1979 and 1980. Decreased yearly maximum levels of calcium, magnesium, chloride, and sulfate were observed in 1981 relative to 1980.

Water quality monitoring for the dewatering/reinjection/discharge program focused on the upper aquifer. The mean concentrations of major inorganic parameters in upper aquifer control wells during 1981 were similar to 1980 means. However, mean levels of TDS, calcium, magnesium, bicarbonate, and sulfate were lower in 1981 relative to 1980. Mean concentrations in near-field wells in 1981 were commonly higher than either 1980 or baseline (1976) means. Far-field mean concentrations in 1981 were similar to 1980 means for most constituents.

The MANOVA for selected upper aquifer water quality constituents indicated significant variability (at the .05 significance level) for all parameters except pH, fluoride, chloride, and bicarbonate for the area main effect. Significant variability for the year main effect was noted only for pH, magnesium, sodium, and marginally for chloride. The interaction term (area x year) was not significant for any constituents. This indicates a lack of change in the relative water quality at control, near-field, and far-field wells over time, although the variability among station types and years is highly significant for some constituents.

Duncan's Multiple Range Tests were used to examine the nature and significance of differences in mean concentrations over time (year) and space (control, near-field, and far-field) in the upper aquifer. Examination of spatial differences indicated that there were no significant differences indicated that there were no significant differences between control and near-field means for conductivity, alkalinity, and sodium. There were no significant differences between near-field and far-field means for sodium. The analysis of means show the general increase in pH in the upper aquifer since the baseline and decrease in sodium and chloride concentrations. Recent years data have been very stable for these constituents. The changes in mean concentrations over time for magnesium and chloride are not significant.

The MANOVA related variance analyses, and the Duncan's Multiple Range Test indicated that although certain constituents vary significantly in time and space, the general pattern of water quality has not changed appreciably over time. Impact-related changes are not apparent from this analysis.

The water levels have been very uniform over the last two years of record for the lower aquifer, indicating an absence of influence from the continuing reinjection operations.

B. MIS Modular Development Area

Monitoring of the MIS Modular Development Area includes sampling of various process ponds, alluvial aquifers and deep aquifers. The focus of this sampling is on water quality.

The East Retention Pond is located adjacent to the MIS process Area. Concentrations of most constituents in this pond increased appreciably in 1981 relative to 1980, a reflection of increased production activities in 1981. This is generally shown by increased conductivity from 1000-3000 micromhos/cm in the first half of 1981 to about 6000 micromhos/cm in the second half of the year. There was no discharge of this higher conductivity water.

The water quality of the eight evaporation ponds sampled during 1981 was quite variable due to variations in operations during 1981. Water was detected during 1981 in piezometers located adjacent to the evaporation ponds but the water quality data indicated that the water was probably due to precipitation rather than pond leakage.

The general water quality at alluvial control wells for the MIS monitoring program has been fairly constant since the baseline (1976). Most of the variability in mean concentrations is due to 1981 calcium and sulfate levels which increased relative to previous observations. Near-field alluvial wells are typically dry. Because these wells only intermittently contain water, resulting in different wells being sampled at different times, the water quality in the near-field is rather variable. Similarly, the water quality of the far-field data set has

been variable in recent years. Temporal trends were not obvious in these data sets.

The concentrations for most major inorganic constituents in the MIS alluvial wells increased in the downstream direction. Typically, maximum concentrations in 1981 were observed at far-field stations. Calcium concentrations, however, were generally higher at near-field than at either far-field or control alluvial wells. This increasing trend in the downstream direction is typical for natural systems and hence no development-related effects are indicated.

The results of the alluvial aquifer MANOVA for selected water quality constituents indicated that, for most major inorganic constituents, significant variability was observed for the main effects of monitoring area or station type (control, near-field, far-field) and year. The interaction term (area x year) was significant only for TDS, pH, and sulfate. Thus, for most constituents, the spatial pattern of water quality variability has not changed significantly over time.

Duncan's Multiple Range Test results indicated that control area means were not significantly different than near-field alluvial well means for sodium and chloride. Near-field and far-field means were not significantly different for TDS, alkalinity, magnesium, chloride, bicarbonate, and sulfate. Thus, control alluvial well water quality tended to be significantly different than near-field and far-field wells.

Beyond an increasing trend in mean pH and perhaps sulfate concentrations, and a small decline in recent years in sodium concentrations, the 1981 means in the alluvial aquifers are not consistent with earlier observations. Most of the observed changes over time, though significant statistically, do not appear to be of great magnitude nor indicative of development-induced impacts on water quality of the alluvial system.

The mean levels of most water quality parameters for upper aquifer control wells for the MIS Area monitoring program in 1981 were somewhat lower than in 1980 and somewhat higher than baseline (1976) means. The general chemical composition of upper aquifer control stations has not changed appreciably since the baseline period.

The mean concentrations of major ions in 1980 in near-field upper aquifer wells were similar to means observed in 1980, however, the means for many ions were lower than baseline (1976) values. A shift from sodium-bicarbonate to a mixed ion system is indicated. The 1981 far-field water quality was generally similar to 1980 observations.

In the upper aquifer wells monitored in 1981 for the MIS area hydrology monitoring program, mean salinity generally decreased in the downgradient direction (from control to near-field to far-field). This trend was mostly attributable to decreases in calcium, bicarbonate, and sulfate concentrations. No impact-related trends, such as increased concentrations in the near-field wells are apparent from these observations.

The results of the MANOVA for selected water quality constituents indicated that, for most major inorganic constituents in upper aquifer wells, significant variability is observed for the main effects of area (station type) and year. Significant variability over the MIS upper monitoring areas was observed for all tested constituents except conductivity and sodium.

Duncan's Multiple Range Tests indicated that all three monitoring areas (station types: control, near-field, far-field) were significantly different for pH, calcium, bicarbonate, and sulfate. Control and far-field upper aquifer wells were significantly different for all constituents.

The examination of means indicated that the concentrations for control stations are generally greater than, or comparable to those for near-field and far-field wells. Exceptions to this generalization are pH and chloride concentrations, which generally increased in the downgradient direction.

The analysis also indicated an increasing trend in pH over time in the upper aquifer, and general decreases in alkalinity, sodium, fluoride, and chloride concentrations since the baseline measurements. The mean concentrations in recent years have been fairly stable, and development-related impacts are not evident.

Lower aquifer well GS-15L is included as a control station in the MIS Area hydrology monitoring program. The 1981 mean water levels, pH, and

water temperature data were similar to observations for previous years. The 1981 mean TDS and alkalinity concentrations were appreciably greater than means observed in 1980. This was caused principally by increases in sodium and bicarbonate ion concentrations. These data reflect an increasing trend in concentrations of these constituents since the baseline period. The trend is probably related to upper-lower aquifer interconnections during the baseline period. The most recent data are more characteristic of lower aquifer water quality.

C. Lurgi Plant Site

The monitoring program for the Lurgi plant site was designed to monitor the hydrologic effects of the proposed Lurgi demonstration project facilities. Construction of this facility, to be located north of Tract C-a, has been delayed. Hence, hydrological data collection and analysis is currently oriented to defining the baseline or pre-development conditions in the plant site area streams, springs, alluvial aquifers, and deep aquifers.

Four spring and seep monitoring stations function as control stations for the Lurgi plant site. The mean concentrations of water quality parameters for these stations during 1981 were similar to 1980 observations. No appreciable temporal trends are indicated by these data.

The increased conductivity relative to earlier years that was indicated for the alluvial control well GS-S24 for 1981 was also reflected in the

water chemistry data (no water chemistry data were collected at GS-S24 during 1980). Water quality during 1981 at near-field alluvial wells for the Lurgi plant site exhibited appreciable increases in mean total dissolved solids compared to earlier years (2051 mg/l versus 1379 and 1420 mg/l in 1977 and 1976, respectively). The change was due to moderate increases in most major ions and large increases in mean sulfate levels (923 mg/l in 1981 versus 594 and 597 mg/l in 1977 and 1976, respectively). Water chemistry was not monitored at these near-field stations during the 1978-1980 period. The mean concentrations of most major water quality parameters at the far-field alluvial wells decreased in 1981 as compared to 1980 (the only other year of record).

As expected, the concentrations of dissolved constituents in alluvial wells monitored for the Lurgi plant site program generally increased in the downgradient direction (control to near-field to far-field). The mean concentrations at near-and far-field alluvial wells were fairly similar during 1981, while concentrations at the control well were appreciably lower than either of the other two station groups.

The MANOVA of the Lurgi plant site alluvial aquifer monitoring data indicated significant variability for the area (station type) main effect for all of the selected constituents except fluoride. Significant variability for the year main effect was observed for all constituents but calcium, sodium, fluoride, and chloride. The interaction term (area x year) was nonsignificant for all constituents

at the 0.05 level except TDS and conductivity and was only slightly significant for these two constituents.

Duncan's Multiple Range Tests for the area (station type) main effect showed two patterns. For TDS, conductivity, magnesium, bicarbonate, and sulfate ions, all three areas (control, near-field, and far-field) were significantly different. For pH, alkalinity, calcium, sodium, and chloride, the control and near-field groupings were not significantly different but were different from the far-field stations.

Most of the significant increases in means among the station groupings and over years are the result of 1981 sampling of the far-field stations (GS-S28, GS-S29, and GS-S30 well series) which exhibited appreciably higher levels of major inorganics than the near-field tract wells during the 1975-79 period.

The 1981 mean concentrations of most inorganic constituents in upper aquifer control wells were slightly higher than 1980 means. Decreases in sodium and sulfate concentrations resulted in an overall decrease in the mean total dissolved solids level. The concentrations of all of these constituents except sodium have increased considerably since the baseline period (1976). To a large extent, this reflects the process of equilibration in deep aquifer wells rather than the effects of development activities.

Water quality data from sampling of near-field upper aquifer wells exhibited a general increase in concentrations of many major inorganic

constituents in 1981 as compared to 1980. The increase was due largely to sodium, magnesium, and sulfate concentrations.

Mean concentrations of most constituents observed in 1981 at far-field upper aquifer wells were generally similar to or lower than 1980 mean concentrations. The concentrations observed in 1980 and 1981 were appreciably lower than the means observed during the baseline (1976). The decline was exhibited mostly in concentrations of calcium, magnesium, bicarbonate, and sulfate.

No consistent spatial trends were apparent in the 1981 mean and maximum concentrations. The near-field upper aquifer wells exhibited the highest mean TDS due to relatively high alkalinity (bicarbonate) levels. However, the near-field wells had the lowest mean sulfate concentration during 1981. Concentrations of magnesium and sodium were fairly similar across the three types of wells, but calcium concentrations decreased along the control near-field far-field gradient.

The MANOVA of upper aquifer water quality data indicated significant variability for all constituents tested for the area (station type) main effect. The year main effect was significant for all constituents except calcium, magnesium, fluoride, and sulfate. The interaction term (area x year) was significant for TDS, conductivity, pH, calcium, bicarbonate, and sulfate.

Duncan's Multiple Range Tests for the area (station type) main effect showed that the near-field means were not significantly different from

the control of far-field upper aquifer well means for TDS, conductivity, calcium, sodium, and fluoride.

An increasing trend in the downgradient direction for TDS, conductivity, pH, magnesium, sodium, flouride, and sulfate is shown by these data. Alkalinity (and bicarbonate) exhibited maximum means in the near-field wells. The TDS, sodium, and chloride means in the upper aquifer for 1978-81 are not significantly different nor are any o the yearly means for conductivity and bicarbonate. The increasing trend over time for pH and alkalinity is as observed for other upper aquifer monitoring elements.

6.1 EXPERIMENTAL REVEGETATION ON SURFACE DISTURBED SITES

Experimental revegetation Plot R-1, located on a northwestern exposure, had average coverage over the 16 treatment combinations of 43.1 percent for all species encountered during 1981. Planted grasses, specifically wheatgrass (*Agropyron*) species and, to a lesser extent, green needlegrass (*Stipa viridula*), accounted for 49 percent of the total R-1 average. A statistical comparison of 1981 grass coverage data between treatment combinations exhibited no significant main or interaction effect differences (= 0.05). However, comparison of data over the five sampling years indicated that planted grass coverage was significantly higher in 1980 and 1981 than for the previous three years. The biomass of planted grasses averaged 599.1 kg/ha over the 16 treatment regimes. A comparison of 1981 biomass data exhibited no significant differences (= 0.05) for main or interaction effects. However, when data from 1981 and 1978 were compared, the production of planted grasses was significantly higher in 1981 than in 1978.

Planted forb coverage averaged 10.5 percent over the treatment combinations and was responsible for 24 percent of the total R-1 cover. The dominant forb species was Lewis flax (*Linum lewisii*), yellow sweetclover (*Melilotus officinalis* var. *Madrid*), and cicer milkvetch (*Astragalus cicer* var. *Lutana*). For the 1981 data, planted forb coverage was significantly higher (= 0.05) on the plots in Block 2 than on the other two blocks. Comparison of data over the sampling years indicated significantly higher planted forb coverage during 1980 and 1981 than in the other years. The biomass of planted forbs

averaged 152.3 kg/ha over the 16 treatment regimes. The 1981 data did not exhibit any significant differences (= 0.05) when compared using a three-way ANOVA. However, there was significantly higher forb production in 1981 than what was encountered in 1978.

The higher planted grass and forb production in 1981 when compared to 1978 is probably due to an increase in moisture over the years. Data from the rain gauges at R-1 indicate that moisture has steadily risen from 4.83 in. in 1978 to 9.38 in. in 1981.

Coverage of planted shrubs averaged 2.7 percent, which was 6 percent of the total coverage. Rabbitbrush (Chrysothamnus nauseosus and C. viscidiflorus), winterfat (Ceratoides lanata) were the most dominant planted shrub species. There were no statistical differences (= 0.05) when the 1981 data was analyzed with a three-way ANOVA. Comparison of planted shrub coverage over sampling years exhibited significantly lower cover after one year's growth than that exhibited in subsequent years.

Experimental revegetation Plot R-2, established in 1975 on a southeasterly slope, had average cover of 30.1 percent for all species encountered during 1981. The planted grasses were responsible for 39.5 percent of this total and had average coverage of 11.9 percent. Wheatgrass species and Indian ricegrass (Oryzopsis hymenoides) were the dominant planted grasses, while green needlegrass was a common subordinate species. There were no significant differences among treatment regimes (= 0.05) when the data collected in 1981 were analyzed, but there were significant differences when the planted grass

cover data was compared among years. Planted grass coverage was significantly higher in 1980 than in 1981, both of which are significantly higher than any of the other three sampling years. Average planted grass biomass was 270.5 kg/ha and was primarily made up by those grass species with the highest coverage. No significant difference among treatment regimes (= 0.05) were indicated by analyses of the 1981 biomass data. There were, however, significant differences when the data were compared among years. Production of planted grasses was significantly greater in 1981 than in 1978.

Coverage of planted forbs averaged 7.3 percent over the 16 treatment combinations and was responsible for 24.3 percent of the total R-2 coverage. The prominent forb species were Lewis flax and cicer milkvetch, with yellow sweetclover occurring as a subordinate forb. A statistical comparison of 1981 forb data exhibited no significant main or interaction effect difference (= 0.05). When data from all years were analyzed, coverage of planted forbs in 1980 and 1981 was significantly higher than in previous years. These differences in forb coverage seem to be related to a block x mulch x fertilizer interaction effect with no corresponding main effect differences. Production of the planted forbs averaged 150.1 kg/ha. Most of this production consisted of Lewis flax, cicer milkvetch, and yellow sweetclover. When the 1981 planted forb biomass data were analyzed by the threeway ANOVA, no significant differences among treatment regimes (= 0.05) were noted. Significant differences did arise when data for 1978 and 1981 were compared. Planted forb biomass was significantly greater in 1981 than in 1978.

Planted shrub coverage accounted for 18.6 percent of the R-2 total with average cover over the different treatment combinations of 5.6 percent. The two rabbitbrush species and winterfat were the dominant planted shrub species. Based on 1981 data, no significant main or interaction effect differences were noted. However, a comparison of data over the five sampling years exhibited significantly higher coverage in 1980 and 1981 than in the previous three sampling years. These differences may be attributed to differences in the mulch treatments as well as significant block x mulch x interaction effects. Plots that were hydromulched had significantly greater shrub coverage than plots with the other three mulch treatments (no mulch, crimped straw, and straw covered with netting).

The total biomass on Plot R-2 for the clipped grass and forb species averaged 492.1 kg/ha. The planted grasses were responsible for 55 percent of the total compared to 30.5 percent for the planted forbs.

A comparison between data from Plots R-1 and R-2 and data from the neighboring, undisturbed sagebrush community revealed that production on these revegetation plots exceeded that of the sagebrush plant community. Herbaceous production averaged 435.3 kg/ha during 1981 along the sagebrush production transects, compared to 831.0 kg/ha for Plot R-1 and 492.1 kg/ha for Plot R-2.

6.2 EXPERIMENTAL REVEGETATION ON A SIMULATED PROCESSED SHALE DISPOSAL SITE

Coverage averaged over all treatment combinations for species present on Plot R-3 during 1981 was 37.5 percent on the treatment portion (underlain by processed shale) and 38.4 percent on the control portion (not underlain by processed shale). The highest coverage on the treatment portion was recorded on the hay mulch/low seeding combination, while the lowest coverage was found on the no mulch/low seeding combination. On the control portion, the highest coverage was found on the hay mulch/high seeding combination; the lowest coverage was obtained on the no mulch/low seeding combination.

The prominent planted grass species encountered on both the control and treatment portions of Plot R-3 were wheatgrass species and Indian ricegrass. The most prevalent invading grass species were cheatgrass (Bromus tectorum) and crested wheatgrass (Agropyon cristatum). Coverage of all planted grasses averaged 21.4 and 24.0 percent on control and treatment portions, respectively. A comparison of 1981 coverage data for all planted and invaded grasses indicated that significant differences (= 0.05 and 0.025 for plant and invaded species, respectively) exist among the various seeding regimes, but not among fertilizer treatments or between shale-no shale substrates. Planted grass cover was significantly higher on areas seeded at 28 kg/ha than those seeded at 17 kg/ha. Invading grasses exhibited significantly higher coverage on plots seeded at the lowest rate (17 kg/ha) than plots seeded at either the medium 22 kg/ha) or the high (28 kg/ha) seeding rate.

Planted grass coverage on Plot R-3 was highest during 1979 and has decreased slightly since that time. The decreased coverage noted during 1980 and 1981 is a result of sampling aboveground biomass during the 1979 season via destructive techniques (coverage estimates in subsequent years were made on the same quadrats upon which biomass was measured in 1979). Data for 1980 and 1981 indicate that planted grasses recover quickly from the impact of destructive sampling, which simulates heavy grazing pressure. However, the coverage of planted grasses the second year after destructive sampling is still significantly lower (= 0.05) than that recorded in 1979. Furthermore, concomitant with reduced coverage of planted species, coverage of invaded grasses was significantly higher (= 0.05) in 1980 than during any other sample period.

Planted forb coverage values averaged over all treatment combinations within control and treatment portions of Plot R-3 were 8.9 and 5.7 percent, respectively. The higher coverage of planted forbs on both the control and treatment portions of Plot R-3 was recorded on areas which were hydromulched and seeded at 17 kg/ha (the lowest rate). Cicer milkvetch was the dominant forb throughout Plot R-3; however, Lewis flax and yellow sweetclover were subordinate forbs commonly occurring on both the control and treatment portions of the site. A comparison of 1981 coverage data for all planted and invaded grasses indicated that there were no significant differences (= 0.05) in coverage based on any of the treatments tested.

Planted forbs coverage has increased subsequent to clipping quadrats for biomass determinations in 1979 (3.5 percent in 1979; 7.3 percent in 1981). This increase may be related to decreased competition from grass species. Statistical comparisons of forb coverage data among years indicate that 1981 coverage, though similar to that for 1980, was significantly higher (= 0.05) than that recorded for 1977, 1978, or 1979.

Planted shrub coverage averaged 4.2 and 4.6 percent on control and treatment portions of R-3, respectively. The greatest planted shrub coverage on the control portions was found on plots which were seeded at 22 kg/ha and hydromulched, whereas the seeding rate of 28 kg/ha followed by hydromulching resulted in the highest planted shrub coverage on the treatment portion of the study site. Winterfat and fourwing saltbush (*Atriplex canescens*) were the dominant planted shrub species. Broom snakeweed (*Gutierrezia sarothrae*) was the most common invading shrub species encountered on both the control and treatment areas. A comparison of total shrub coverage among all treatment combinations for 1981 showed no significant differences (= 0.05) based on substrate, mulch, or seeding rate treatments.

Coverage of planted shrub species on the quadrats sampled declined from a high of 16.7 percent in 1979 to 4.4 percent in 1981. Coverage recorded during 1981, 1980, 1978, and 1977 is significantly lower (= 0.05) than that noted for 1979. Because shrub species are not expected to readily produce growth from rootstocks as do many grasses and forbs,

the planted shrubs on Plot R-3 did not recover from destructive sampling conducted in 1979 as well as the grass and forb species.

No significant differences (= 0.05) between electrical conductivity (EC) in soils from control and treatment portions of the study site were noted during 1981. As expected, EC increased with depth in the reconstructed soil profiles on both the control and treatment sides of R-3, probably as a result of the increased amount of unweathered parent material. Electrical conductivity data suggest that the rubblized overburden materials within the reconstructed soil profile are continuing to prevent capillary migration of dissolved salts from the processed shale into the surface growth medium.

6.3 EXPERIMENTAL REVEGETATION GREENHOUSE STUDIES

Greenhouse studies were undertaken to assess the revegetation potential of Lurgi processed shale. The objectives of the studies were (1) to determine the concentrations of boron (B), molybdenum (MO), fluorine (F), arsenic (As) and selenium (Se) in plants grown in Lurgi processed shale, as well as in various depths of topsoil and subsoil over the Lurgi processed shale; (2) to determine plant growth and response in various growth mediums, using techniques including biomass measurements of roots and shoots; (3) to investigate the suitability of Lurgi processed shale as a medium for seed germination; and (4) to assess the potential of stockpiled Tract C-a topsoils to infect roots with beneficial vesicular-arbuscular mycorrhizal fungi.

Five plants species (five replicates per species) were grown for six months within 11 variations of topsoil, subsoil and/or capillary barrier depths over Lurgi processed shale. The treatments, including two topsoil controls and one shale only treatment, were as follows:

1. 15 cm topsoil (control)
2. 30 cm topsoil (control)
3. 15 cm shale
4. 15 cm topsoil, 15 cm shale
5. 15 cm topsoil, 15 cm subsoil barrier, 15 cm shale
6. 15 cm topsoil, 30 cm subsoil barrier, 15 cm shale
7. 30 cm topsoil, 15 cm shale
8. 30 cm topsoil, 15 cm subsoil barrier, 15 cm shale
9. 30 cm topsoil, 30 cm subsoil barrier, 15 cm shale
10. 15 cm topsoil, 15 cm gravel barrier, 15 cm shale
11. 15 cm topsoil, 30 cm gravel barrier, 15 cm shale

The differential response of plants grown in the various treatments showed that growth in 30 cm of topsoil was superior to that in only 15 cm of topsoil. Adding an additional layer of subsoil below the topsoil improved plant growth. The use of pea gravel as a capillary barrier did not result in significantly better growth than that recorded for the 15 cm topsoil control ($_=$ 0.05). The Lurgi shale underlying the various topsoil/subsoil growth mediums did not appear to hinder plant growth. Average aboveground production was nearly identical among the five species tested. Furthermore, there was no significant difference in root biomass among the treatments.

The migration of boron, molybdenum, and fluoride from the processed shale into the overlying soils did not appear to occur under the conditions of this study. In fact, there appeared to be losses of the water soluble B, Mo and F from the topsoil/subsoil growth mediums due to leaching. A reduction in electrical conductivity indicated that leaching of salts from the surface growth mediums also occurred. The Lurgi process appears to cause a reduction in the availability of B and Mo in comparison to the TOSCO and U. S. Bureau of Mines processes. The uptake of B by plants was not significantly different ($_=$ 0.05) among any of the treatments and topsoil controls. The B levels recorded were well within the tolerable levels for plant growth and animal uptake. Molybdenum also occurred in relatively low values in plants grown under all treatment conditions. However, the Mo content was significantly higher ($_=$ 0.05) in plants grown in the shale-only as well as 15 cm topsoil over shale treatments when compared with topsoil controls (15 and 30 cm topsoil only). The fluorine content of plants grown in straight Lurgi processed shale reached high levels. The fluorine content dropped drastically, however, when only 15 cm of topsoil was placed over the shale. Similarly, the Se level in plants grown in straight shale was very high, but was reduced greatly with an application of 15 cm of topsoil over the shale. The low levels of arsenic measured in all plants and treatment profiles analyzed appear to offer no potential hazards to plant growth or for grazing animals.

Seed germination for the 12 species tested was very poor in or on Lurgi processed shale. The three germination treatments (surface, 1 cm and 2.5 cm) were not significantly different; however, all three exhibited

significantly lower (= 0.05) germination than that recorded on topsoil controls.

Under greenhouse conditions, the five test species grown in the topsoil/subsoil surface growth media from Tract C-a were found to be naturally inoculated with vesicular-arbuscular mycorrhizal fungi (VAM). Underlying shales and/or a capillary barrier had no discernible impact on VAM propagation in the Tract C-a topsoils.

6.4 TOXICOLOGY

Extensive toxicological and industrial hygiene studies are being conducted by the U. S. Department of Energy (DOE) Oil Shale Task Force and RBOSC on the products and by-products of MIS and Lurgi oil shale retorting. These studies are designed to characterize the physical and chemical properties, to determine biological activities, and to assess potential worker exposure and environmental hazards of oil shale process materials.

Preliminary results of the DOE research on MIS Retort Zero indicate that the sour water was more dilute than process waters for other in situ retorts. The crude shale oil, on the other hand, contained more sulfur than other shale oils. Analyses of the off-gases indicated that mercury and nitrogen oxide concentrations generally increased as the burn progressed. Testing of stack particulates demonstrate that most of the particulate organic material consisted of polycyclic aromatic hydrocarbons. Analyses of soil samples showed that there are

significant differences in natural background concentrations of mercury among different soil types.

Sampling of hydrogen sulfide and dust conducted during the Retort Zero burn indicated that the Threshold Limit Values for 8-hr exposures to hydrogen sulfide and dust were not exceeded. Additional data on the DOE toxicological and other DOE-sponsored studies will be available in the near future.

Screening tests were conducted to determine the toxicity and mutagenicity of various MIS generated materials. Toxicity tests using a bioluminescent strain of bacteria and the test organisms indicated some toxicity associated with certain MIS sour waters. Both the Ames and sister chromatid exchange tests of MIS shale oil yielded positive results for mutagenic activity.

RBOSC-sponsored toxicology tests conducted by IIT Research Institute are presently underway for both MIS and Lurgi-generated materials. The battery of tests include acute toxicity tests, tests to evaluate dermal and ocular irritation, and genetic assays such as the Ames Test, forward mutation assay and dermal cytogenetics tests. These tests are scheduled to be completed in 1982.

6.5 RUN-OF-MINE LYSIMETER

RBOSC, in cooperation with the EPA, the USGS, and the DOE Task Force, is conducting leaching studies on stockpiled run-of-mine ore in order to

determine the chemical characteristics of leachate generated from raw shale in the field and to compare these results with those from laboratory tests on the same materials. This comparison is being conducted to determine the importance of such factors as percolation rates (residence time), wetting and drying cycles, and other weathering factors on leachate quality.

The field lysimeter tests were initiated in mid-June, 1980. The results of the tests, both leachate volumes and chemical analyses, were published in a First Annual Progress Report for the period April 1, 1980 - May 31, 1981, by Dr. David McWhorter (1981). A summary of this report was included in MDP 8. Since May 3, 1981, additional samples have been collected and analyzed. The lysimeters have been monitored only for volume (no sampling) since November 1981. Publications of a second annual progress report is expected in the Spring of 1982. The relevant portions of the forthcoming report will be included in the next MDP monitoring report.

6.6 MULE DEER HABITAT MODIFICATION

During RBOSC's commercial operation, disturbance of the land will result in the loss of forage for wildlife, primarily mule deer. One means of mitigating these losses is to increase the mule deer carrying capacity of undisturbed areas to maintain the overall carrying capacity at, or near, predevelopment levels. RBOSC initiated an experiment in 1980 to determine the feasibility of producing such increases in carrying capacity using habitat modifications techniques.

The habitat modification experiment was designed to evaluate the effects of several factors critical to increasing deer carrying capacity: (1) snow depth, (2) moisture availability during the growing season, (3) selective brush removal, (4) quality forage, and (5) fertilization. Four 5-m corridors were chopped in each of two treatment areas, such that a differential accumulation of snow should occur between the two areas, thereby enabling an evaluation of the effects of such accumulation on forage production and utilization as well as deer movement. Half of each treatment area was seeded and fertilized with ammonium nitrate. Eight treatment regimes were thereby established. Control areas were also established in undisturbed sagebrush adjacent to each of the treatment areas.

Twelve permanent vegetation transects were established (four in each treatment area and two in each control area). Density of shrub species, percent cover of shrub species, and percent cover of herbaceous species were estimated within eight plots on each transect.

Significantly higher cover estimates and greater densities, as indicated by t-tests, were noted on corridors oriented parallel to the prevailing winds than on corridors oriented perpendicular to the wind. Additional analyses using three-way ANOVA's showed that the corridors oriented parallel to the wind had significantly higher cover on fertilized areas (ammonium nitrate applied at 120 pounds per acre) than on areas which received no fertilizer. Significantly higher densities were recorded on the areas which had been rotochopped as compared to those which were not chopped. No significant differences in cover or density, as based on

the treatments tested, were noted on the study site oriented prependicular to the wind. Assessments in subsequent years will be necessary before definitive trends in cover and density can be identified.

6.7 SHRUB GROWTH ENHANCEMENT ON A SIMULATED MINE SITE AND/OR DISPOSAL PILE BENCH

A simulated mine site/disposal pile bench was constructed on Tract C-a in early 1982. The simulated bench is designed principally to evaluate the effects of water harvesting techniques on shrub growth. In addition, the effects of artificial irrigation, topsoil depth, and grazing are to be evaluated. The bench is designed to concentrate available moisture in certain areas, using water bars and variations in slope. Various combinations of fencing and topsoil applications will also be tested. Shrubs will be planted in each of the resulting treatment areas in the spring of 1982. Shrub growth will be evaluated on a yearly basis, to identify any effects of the various treatments on shrub growth. The success of the water harvesting techniques will be evaluated by periodic measurements of soil moisture content at fixed locations. The results of these evaluations will be included in subsequent MDP Environmental Monitoring Reports.

6.8 RANGE EXCLOSURE

The range exclosure, located on Airplane Ridge near the western boundary of Tract C-a, had an average cover of 6.6 percent for the four

compartments. Compartment B had a high herbaceous cover of 9.17 percent, whereas the lowest herbaceous species coverage values were 6.92 and 5.64 percent, on compartments A and C, respectively. Grasses, primarily the wheatgrass, bluegrass (*Poa*), and Indian ricegrass species, accounted for the majority of the coverage on the four compartments. The predominant forbs were lobeleaf groundsel (*Senecio multilobatus*) for compartments A and B, northern sweetvetch (*Hedysarum boreale*) for Area C, and scarlet globemallow (*Sphaeralcea coccinea*) for compartment D. The statistical analyses comparing herbaceous coverage between compartments exhibited no significant differences (= 0.05).

Average biomass for the range exclosure was 130.79 kg/ha. Production values were 89.99. 197.31, 146.72, and 89.13 kg/ha for compartments A, B, C, and D, respectively. The predominant grass and forb species responsible for most of the herbaceous coverage also made up most of the herbaceous biomass. The statistical comparison for 1981 biomass data between the four compartments exhibited no significant difference (= 0.05) for either grasses or forbs.

6.9 SUPPLEMENTARY SULFUR DIOXIDE MONITORING PROGRAM

The supplemental sulfur dioxide monitoring program showed no concentrations approaching either the NAAQS or PSD Class II increments. The highest impacts were very transitory and showed a great deal of variability both in time and space, sometimes occurring in Corral Gulch and sometimes on higher ground near Site 1. The highest concentrations were found near the west boundary of the tract, with decreasing

concentrations on higher ground further to the west. Elevated concentrations found simultaneously at Site 1 and in Corral Gulch suggest that the plume is widely dispersed at least part of the time.